American Denture Society and Pacific Coast Society of Prosthodontists Joint Meeting,
San Francisco, Oct. 14 and 15, 1955

THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 5 SEPTEMBER, 1955 NUMBER 5

UNIVERSITY OF MICHIGAN
SEP 26 1955
DENTISTRY LIBRARY

Official Publication of

THE ACADEMY OF DENTURE PROSTHETICS

THE AMERICAN DENTURE SOCIETY

THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS

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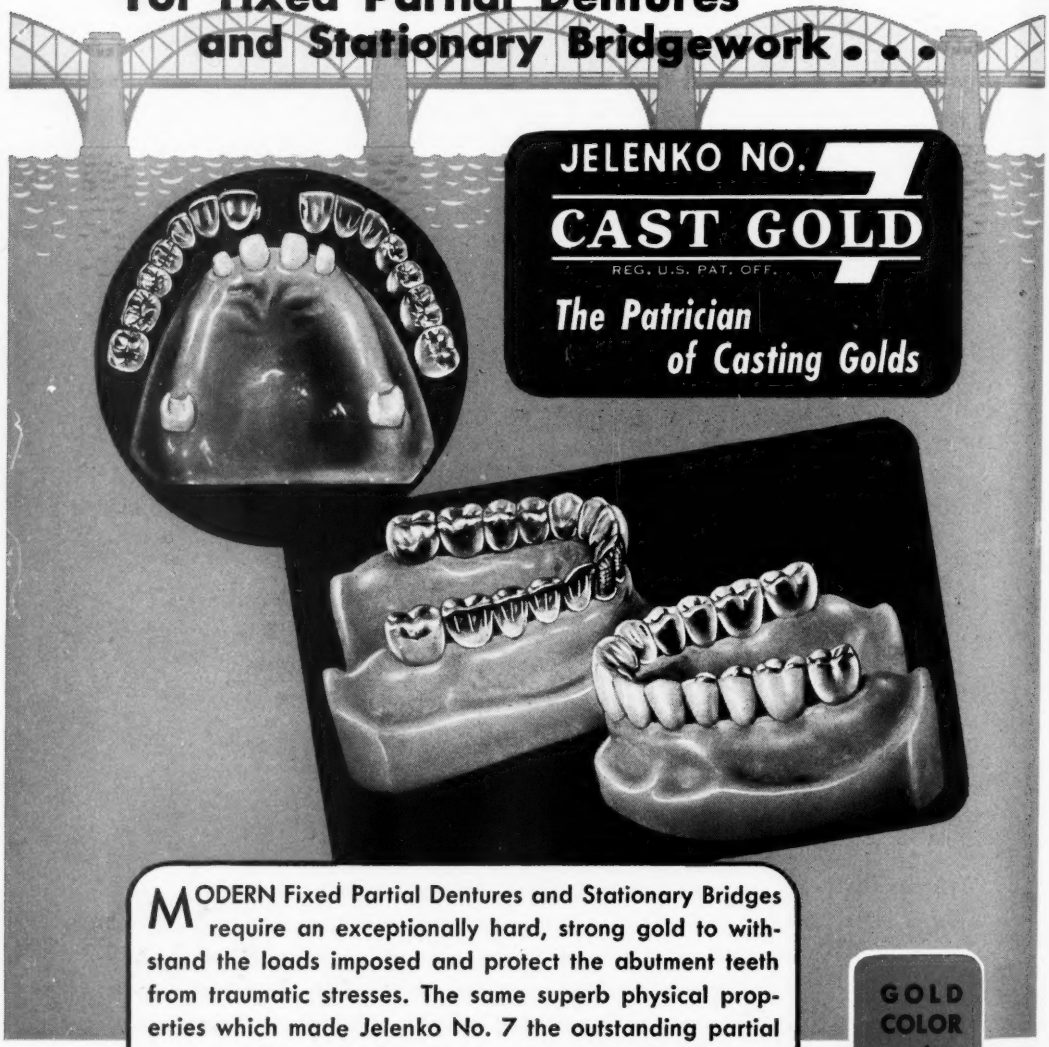

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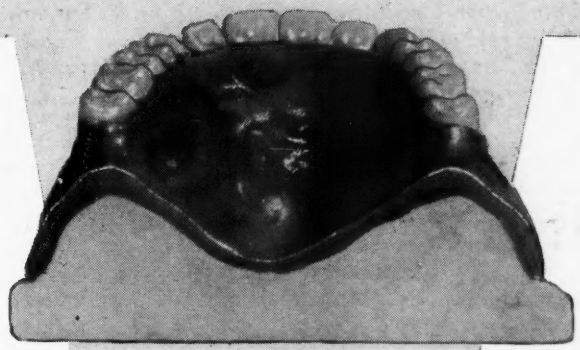

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The Journal of Prosthetic Dentistry

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Vol. 5. No. 5, September, 1955. Journal of Prosthetic Dentistry is published bi-monthtly by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription Price: United States and its Possessions per Year $9.00; Canada, $9.25: Foreign, $10.00. Entered as second class matter March 13, 1951 at the Post Office at St. Louis Missouri, under the Act of March 3, 1879. Additional entry authorized at Jefferson City, Missouri. Printed in the U. S. A.

THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 5 **September, 1955** **No. 5**

THROUGH THE EYES OF THE EDITOR

John P. Frush and Roland D. Fisher introduce a new concept of esthetic possibilities in complete dentures in their discussion of "dentogenic" restorations. The individual techniques which are applied are not necessarily new, but they are used with a clearer over-all objective. The concept furnishes correlated guides to the harmony of the dentures with the sex, personality, and age of the patient. These guides will serve to eliminate a mechanical appearance of dentures and to make possible an improvement in the patient's appearance. This is particularly important when one considers the procedures which improve the appearance of the *teeth,* but which have the opposite effect upon the appearance of the *patient.* Too often, the basic position of the anterior teeth is changed to make the upper and lower teeth have a better relation to each other. This changes the support of the soft tissues around the mouth and causes the lips to move unnaturally. In this article is shown the way to an improvement of the patient's appearance *without* violating the basic anatomic factors in esthetics.

This "Introduction" outlines the possibilities of the concept and emphasizes the importance of esthetics to the happiness of patients. It is the first of six articles which should provide a stimulus to dentists in their efforts to serve their patients better.

George Wood Clapp recalls the early haphazard method for anterior tooth mold selection and tells the story of J. Leon Williams' contributions to this problem. There was considerable resistance to the application of Williams' ideas when they were first offered to manufacturers. It was only after the profession approved the idea, that the manufacturers attempted to bring order out of the existing chaos. The problem is difficult at best, and the guides which were suggested were tremendously helpful. The selection system gave dentists a starting place for the development of restorations which were in harmony with the shape of the patients' faces. With this as a background, further development of esthetics is possible within the limits of the ability of dentists to recognize and develop harmony in the arrangement of teeth. Dr. Clapp's tribute to the work of J. Leon Williams is well deserved.

Herbert T. Kelly discusses the psychosomatic approach in prosthodontics. He explains some of the perplexing problems involved in the reactions of patients to dentures. A knowledge of the principles of psychosomatic medicine can be of assistance to prosthodontists if they are understood. It is apparent that there is a definite relation between psychosomatic conflict and the general and oral health of patients.

Raymond Levao discusses the hinge axis record in relation to restorative procedures. He questions the value of observations of jaw movements produced in a cadaver by externally applied forces. This seems to be logical since this activity ignores the neuromuscular system which plays such a vital part in jaw movement and position. He admits that the hinge axis may exist in patients but that it is not necessarily within the condyles. It seems that, if it is located in a given patient, it is not important whether it is *in* the condyles or *near* them so long as it is properly related to the articulating instrument. He points out certain difficulties in locating and transferring it to the articulator and notes some articular deficiencies. While he doubts the value of the hinge axis record in restorative procedures, it is a procedure which is used in

an attempt to accomplish certain objectives in the ultimate occlusion. Like most other procedures in prosthodontics, it is not fool proof. Further, the exact location of the hinge axis does not assure a perfect occlusion in the completed restorations because there are many other factors involved. However, if its proper location and transfer helps those who emphasize its importance to provide better occlusion for their patients, it is worth while.

John B. Lazzari describes the use of a simple arbitrary face-bow. He recognizes the errors which are possible in its use but points out that the errors of mountings are of smaller magnitude than if mountings are made without a face-bow. The technique described is not new, but serves as a reminder that it does not take much time to use a face-bow, and that its use makes the mounting of casts a simple procedure.

Barnett Kessler has analyzed the various functions of the tongue in relation to prosthodontic restorations. The structure of the tongue is related to the other structures with which dentists are concerned in such a way that the cause of some denture difficulties are indicated. His classification of tongues should serve as a guide in predicting certain difficulties and as an indication to a means for preventing trouble. It is obvious that the tongue is much more important to the success of dentures than is generally recognized.

Oliver C. Applegate discusses the various factors involved in the partial denture base. He points out the two ways in which the base may function and the variations in procedures which are necessary to meet the requirements in each instance. He places the proper emphasis upon the importance of stability and suggests ways to provide for it. He describes a combination impression procedure which seems to meet his standards. The technique is not too complicated and it is effective for the purpose. It seems that not enough attention is given to this phase of partial denture construction in routine practice. A consideration for the variation in the characteristics of the tissues which support partial dentures should make this evident. He sets forth the desirable qualities of the materials from which the bases are made, and analyzes these materials on the basis of the ideal requirements. This provides a logical basis for the choice of base materials and points out the need for better materials.

Aluizio Gonçalves describes the equipment and procedure for making combination internal and external attachments for removable partial dentures. If the technique is accurately carried out, the retainers and stabilizers which he describes should be efficient, and, at the same time, protect the abutment teeth from caries.

L. Rush Bailey describes a technique for making an acrylic resin tray for the new rubber base impression materials. The procedure is not too complicated, and it provides the advantages of an accurately fitted tray to carry, control, and confine the impression material. Apparently, good results have been obtained by this material when it is used in this type of tray.

Elliot Feinberg discusses the various materials used for making master casts for fixed restorations. They all seem to have some deficiencies or disadvantages when the entire impression is made from any one alone. He suggests a combination impression made in plaster and alginate which seems to give greater accuracy for relating castings to each other on the master cast.

I. Norton Brotman emphasizes the importance of complete arch casts for fixed restorations, and describes a combination plaster and hydrocolloid impression for making these casts. The procedure is relatively simple and has definite advantages over some other methods.

Max Kornfeld emphasizes the importance of a knowledge of the anatomy and physiology of the oral organ in his discussion of the problem of function in restorative dentistry. He points out a common and unfortunate attitude within the dental profession of following a technique without inquiring into the reasons for it or checking it against known fundamental principles. The physiologic tolerance of the patient was shown to be of primary consideration. Various biologic factors are discussed in relation to the problem. The hinge axis is considered to be very important. This certainly is true, but only as a means to an end. The location of the hinge axis assists in the registration of other maxillomandibular relations, but to say that "a centric relation record cannot be checked" is open to question. The accuracy of centric relation records *can* be

checked by several methods, provided the dentist uses the proper procedures and approaches the checking with a willingness to find the record incorrect. In reality, centric relation is a positional relation of the mandible to the maxillae, which (if it is correctly located) will coincide with the posterior terminal hinge axis positional relation of the mandible to the maxillae *at the same vertical* dimension. It is true that the accurate location of the hinge axis will make it easier to *maintain* the centric relation mounting on an articulator, but it will not make the *recording* of centric relation more certain. This depends upon the skill used in controlling the patient while the record is made as well as upon other factors. The statement, "Mastication is carried out almost wholly with the Bennett movement," is also subject to question. There can be no doubt that the Bennett movement is an extremely important factor in occlusion and in mastication, when it exists. However, the lateral movement (including the Bennett movement) is obviously so much smaller in magnitude than the opening and closing movements that the latter movements must be considered the major masticating movements. Further, he states that "there may be no Bennett movement in some patients." These patients must use other movements for the mastication of food. There can be no doubt that the more accurately all records are transferred to the articulator and the more accurately the articulator is adjusted (assuming it is capable of the necessary adjustments) the more accurately the occlusion can be developed.

Julian Rieser discusses the various periodontal causes for failures of fixed restorations and the fundamentals of the biomechanical concept. He emphasizes the importance of the "bone factor" in diagnosis. Because of the difference in bone from patient to patient, it should be evaluated for each patient, regardless of the type of restoration to be made. He cites two important biologic factors in the maintenance of periodontal health. He analyzes the mechanical designs of fixed restorations in relation to the problem of protecting the periodontal attachments and the bone supporting the abutments. The ideas expressed seem to be sound.

Arthur Edward Kahn describes a technique for the use of reversible hydrocolloid in the construction of porcelain jacket crowns. This is a different application of a material which is being widely used for metallic restorations. When it is used with care, the results indicate that it is a practical procedure. It seems to have advantages over some other techniques for making dies for porcelain jacket crowns.

Marjorie L. Swartz, Ralph W. Phillips, Robert Day, and John F. Johnston report on in vitro tests on the adhesive characteristics of certain resin restorative and cementing materials. The load required to break the cement joint between a gold post and a flat surface of enamel or dentine was measured. Six different resin cements were tested under varying conditions. The variations seem to be particularly significant when cementation was accomplished on a wet surface, a reduced adhesiveness being exhibited. Some resin cements were more effective than others, but no one material had marked superiority. Other observations were made which seem to have clinical significance.

John F. Johnston, Ralph W. Phillips, and Marjorie L. Swartz report on their laboratory and clinical investigation of certain resin restorative and cementing materials. It is essential that these relatively new materials be correctly evaluated as soon as possible, and the large number of cemented restorations observed in this study makes the results significant. They recognize some situations where this type of cementing material is contraindicated, but, otherwise, the resin cement was shown to be equal to and, in some respects, better than others.

K. Asgars, D. B. Mahler, and F. A. Peyton report on their investigations of the effectiveness and accuracy of the hygroscopic expansion technique for dental castings, and describe a method for adding controlled amounts of water to the setting investment. The procedure is relatively simple, and yet it eliminates some of the variables involved in less precise methods. It is interesting to note, however, that they state that accurate casting procedures alone do not insure good inlays. Cavity preparation, pattern formation, and cementation must determine, to a large extent, the effectiveness of the entire procedure.

Carl O. Boucher

INTRODUCTION TO DENTOGENIC RESTORATIONS*

JOHN P. FRUSH, D.D.S., AND ROLAND D. FISHER, D.D.S.

San Marino, Calif., and Glendale, Calif.

EXCEPT FOR THE TERM "dentogenic," there is really nothing new in the field of prosthetic esthetics which has not, at one time or another, been written about, talked about, or at least thought about. Neither this article nor those outlined to follow it purport to encompass the entire field of esthetics; there is still much work to be done. However, in the two-and-one-half years of investigation, and in the hundreds of examples of improved dental esthetics in which dentists at the Swissedent Foundation have participated, we feel that a start has been made. Perhaps by gathering and presenting this material to practicing dentists, we may be able to furnish your imagination with the springboard from which the field of prosthetic esthetics will leap toward its rightful place in modern dental practice.

"Dentogenic" is a coined word meant to convey, in reference to prosthetic dentistry, exactly the same meaning as the suffix *-genic* imports to photograph in the word "photogenic." Precisely, according to Webster's dictionary, that means, "eminently suitable for production or reproduction." In our word "dentogenic," we seek to describe only such a denture as is "eminently suitable" in that, for the wearer, the denture adds to that person's charm, character, dignity, or beauty in a fully expressive smile. "Dentogenics," then, means the art, practice, and techniques used to achieve that esthetic goal in dentistry.

The science and mechanics of prosthetic dentistry have surged steadily forward in the last one hundred years, and particularly in the last forty years. Ironically, since Williams[1] laid down the first simple rules of dental esthetics, around the turn of the century, dentistry had done virtually nothing to elaborate upon his rules, or even to combat the onslaught that mass production and stylized mechanics inadvertently waged to minimize the good that Williams' limited rules offered. Over forty years ago Williams introduced the square, ovoid, and tapering concept of choosing the form of teeth for dentures. A square face deserved square teeth, an ovoid face required ovoid teeth, and a tapered face not tapered teeth. Those were the first and, unfortunately, nearly the last words on esthetics in dentures. Since then you have undoubtedly read articles which started off something like this, "The restorative dentist is concerned primarily with treating esthetic and functional aberrations of the masticatory system." With the introduction of the word "esthetic" in the opening statement, the matter is there allowed to drop, and the

Read before the Academy of Denture Prosthetics in New York, May 5, 1955.
Received for publication Feb. 2, 1955.
*The first of a series of six articles on the subject of Dentogenic Restorations.

following five thousand words treat solely with the very important subject of function. We do not want, in any way, to minimize the importance of function, nor to belittle the commendable strides which have brought greater patient comfort to a larger percentage of the denture wearers in this country today than in any time in history. Our argument is that dental esthetics has lagged behind, somewhere in the era of the foot-treadle and the alloy pot. Instead of remaining there among the curios and antiques, dental esthetics needs to be brought off the shelf, thoroughly renovated, and restored to its rightful vigor and utility in modern prosthetic practice. The new label, "dentogenics," may as well give guidance to our efforts, because with our new artistic approach we shall find ourselves dealing with an unthought-of result which itself may seem as exciting, invigorating, and new as electronics.

FACTORS IN DENTOGENIC RESTORATIONS

At a recent one-day seminar at the Swissedent Foundation, a representative group of about twenty-five practicing dentists was handed two well-made complete upper dentures. These dentures were passed around for inspection, and when everyone had had a chance to handle them, a question was directed to one of the group.

"Would you say that the dentures you just saw were made for a man or a woman?"

"I couldn't say," was the reply, "could be for either one."

Another question: "Well, then, for what age patient would you say that either of those dentures was made?"

"For any age," someone else responded.

"That leaves one more question," the speaker went on. "Would any of you care to hazard a guess as to what type of personality either of those dentures was made for?"

There was an awkward pause until still another dentist spoke up: "Why, either one could be for anybody . . . or an it, for that matter."

The reply was not uncommon regarding dentures under examination. In point of fact, those dentures were entirely too common, the type that can be found in any laboratory, and in advertisements designed to extol good workmanship and high-quality products. They were solid, symmetrical, uniform, and shiny, with a high degree of translucency. As devices for mastication, they bore the great precision of a finely machined tool; and they might just as well have been made *for* a machine tool, as far as the esthetic consideration for the wearer was concerned. As the assembled dentists so readily recognized, there was not the slightest trace of vitality in those well-constructed dentures. All the vital factors of dentogenics were missing: there was neither sex, personality, nor age defined, or even suggested, in the fine workmanship.

In startling contrast there was next handed to the group two other dentures. One upper denture was delicately treated with a slight ascending curve to the incisor line, and with a soft arrangement of teeth. The other was, to look at it in the hand, a grotesque arrangement of craggy teeth, angular and ruggedly spaced. The

first was immediately identified as suitable for a young woman. With but little prodding of the imagination, one could see her as a moderately vivacious person, with a medium pleasant personality. But this, of course, you will say, was the power of suggestion, conjuring up mental photographs of sisters, cousins, and immediately familiar young women. And so it was, but the fact remains that those assembled dentists agreed that the denture shown them was "eminently suitable" as opposed to suggesting "nothing at all."

The craggy, rugged denture was admittedly shocking. It could only have been meant for an old man. Even so, the sex was unmistakable, the age was positively well past middle life, and only the personality was subject to some doubt and speculation. Later on, the group was shown color photographs of a rugged, weather-lined, desert prospector-type of man. He was portrayed first wearing a set of gleaming evenly spaced teeth. He was shown next wearing the rugged, uneven teeth which the dentists themselves had inspected. There was a murmur of amazed approval. What had appeared so extraordinary, even ugly in the hand, was appropriate, suitable, and even flattering in the old man's mouth.

Overillustrated as the point may have been (and it was *not* propounded as a first project for a student of dentogenics), the example did, at least, awaken the group to the fact that, in their own practices, very little thought had ever been given to personalizing and projecting a denture wearer's sex, personality, or age. How far had Williams' original concept of square, ovoid, and tapering tooth forms penetrated their practice? Just far enough to be used as an almost subconscious rule-of-thumb, with little or no consideration of the patient's further vital configuration: whether man or woman, youthful, middle-aged, or old, vigorous or retiring.

It has been said, "There is beauty in age as well as in youth." Actually, we can add a few lines to that truism; we can say, there is beauty in age as well as in youth, but, in fact, age has the edge. Age has something that youth can never have, and that is dignity. When we remove from the mouth of an older person those factors which identify the dignity to which he is entitled, we destroy something. There is no surer way to destroy that dignity than by inserting a neuter-gender, false-type denture into a man's mouth which destroys his masculine personality.

There was once a time when the fear of pain made chronic sufferers of thousands of people who could have been benefited by prosthetic dentistry. Modern dental practices have made enormous inroads against that fear. Comfort, fit, and masticatory utility have been achieved, and the results are rapidly penetrating public knowledge. Why, then, have such a small proportion of the people of this country estimated to need prosthetic aid availed themselves of the dentists' skill? Why, then, among those of our total population who *do* wear dentures, do we have the problem of "overadaptation to dentures?"[2] Obviously, accurate statistics are unattainable, but a couple of probing questions are raised by these facts. First, if so many people are still suffering with imperfect natural dentitions after the fear of pain has been abated, then they must fear something else. Second, if people who have overcome the initial fear of becoming edentulous continue to

struggle along with ill-adapted dentures, then they, too, must be deterred by something else. It is not unreasonable to assume that much of the lingering fear among the first group is, plainly, the aversion to wearing "false teeth"; and, in the second group, a resignation to wearing "false teeth," with the firmly imbedded opinion that there is no improvement available. We may dignify the public's term "false teeth" by calling it an artificial restoration, but we have neither improved the appearance nor detracted from the public apathy by so dignifying the expression. Conventional dentures are still "false teeth" to the people who contemplate them *and* to the people who wear them. The greatest challenge to dentogenics is to destroy that "denture look."

ORIGIN OF DENTOGENICS

Dentogenics did not spring full-blown into being. In 1952, one of the authors* visited Zurich, Switzerland, during a trip abroad. There he met Wilhelm Zech, in whose work he became extremely interested. Zech had an idea that artificial dentures were something more than porcelain blades adaptable to an edentulous residual ridge. Teeth, according to Zech, were instruments of personality and projectors of vitality. This approach to dental esthetics sounded as abstract to Frush as it must to most dentists, until more was learned about this remarkable man, his ideas, his work, and his background. Wilhelm Zech was not a dentist. He was a master sculptor, quite successful in his chosen art. Zech's father was a dentist, and it was for his father that he first began to produce teeth with something more than geometric design. Young Wilhelm Zech, the sculptor, realized that every bone in the human face, as well as throughout the human body, contributes to the total human personality. No less the teeth. In fact, what more than the teeth? As early as 1936, Zech experimented with the molding, spacing, and arrangement of teeth in artificial dentures for his father, with an artist's concept of what *belonged* in a living human's mouth. He ground and formed teeth which, by their configuration, would depict distinct styles and types of personalities: the soft, rounded feminine type; the rugged, coarse masculine type. He changed the standard ovoid, square, and tapering concepts, and added artistic irregularity of surface, unusual proximal formation, vigorous ridges, and subtle body interpretations.

Zech's work inspired Frush to take a new look at dental prosthetics. Just how much had esthetics entered into the actual practice of prosthetic dentistry? Reviewing his own practice, and searching the available literature on dental prosthetic esthetics, he discovered that the answer was, "almost not at all."

THE SWISSEDENT FOUNDATION

From this father-born and son-instrumented idea, the Swissedent Foundation was established in Los Angeles, California, in 1952. Since its inception, over a thousand practicing dentists have visited the Foundation. Ideas are exchanged, photographic results displayed, and the entire field of dental esthetics given full

*John P. Frush.

emphasis, with the many nuances that a thousand different minds can bring to bear upon a single subject. The seminars conducted at the Swissedent Foundation have convened quietly and without fanfare. These men have assembled, discussed the place of esthetic prosthetic dentistry in the profession, and returned to their own practices with a new feeling for and concept of dental esthetics. The Foundation, in its nearly three years of existence, has become the catalyst for the ideas of these many men.

ESTHETICS

Among the primary hurdles was the question, just what do we mean by esthetics? The word "esthetic" stems from the same Greek root as "esthesia," meaning sensibility or sensation. In the noun "esthete," we have one who perceives and enjoys pleasant sensation. Esthetic is the adjective form, meaning "responsive to the beautiful in art or nature." No creative effort, therefore, can be said to be totally esthetic, in the fullest connotation of the word, unless the result of that effort renders a pleasant sensibility to its author and a sensation of fitness and beauty to the viewer. When dentogenics evolved, the full meaning of esthetics was carried into its third dimension: first, the wearer of a dentogenic restoration must have an inner sensibility of well-being; second, the viewer of a dentogenic restoration must perceive beauty or a fulfillment of the wearer's personality in his smile; the third requisite would then follow without cavil, in that the dentist who created the dentogenic restoration would feel deeply rewarded. Dentogenics, then, as a dental prosthetic term developed by the dentists who have attended the Swissedent Foundation, has come to mean the total application of esthetics to prosthetic dentistry. If any part of the meaning of esthetic is left out of a restoration, it is not a dentogenic restoration.

Defining the goal was one thing, describing the steps toward that goal is quite another; and to describe the steps traced and retraced before valid rules were laid down which would lead toward the production of true dentogenic restorations would be diffuse beyond interest. One of the first problems we ran into was the fact that there were so few suitable materials currently produced through which the principles of dentogenics could be interpreted. Today one of the purposes of the Swissedent Foundation is to influence and encourage the production of improved prosthetic products. The next problem encountered was the fact that there was no current laboratory service with sufficient knowledge or training to interpret the advanced concepts of dentogenics. Complete dentogenic procedure becomes more possible every day as these problems are being solved. Practical dentogenics is the combined effort of many men, an exchange of many experiences and ideas; and it is only the essence of those ideas that are included in this article.

THE SPA FACTOR

The SPA factor, the evaluation of Sex, Personality, and Age, as regards the prospective denture wearer, was the first to become fully evaluated. Individually, any of these three vital factors may have been touched upon before. Sears[3] summed

BEFORE

CONVENTIONAL

AND

FALSE

FROM HER FINGER TIPS TO HER SMILE . . . A WOMAN IS FEMININE.

AFTER

DENTOGENIC

AND

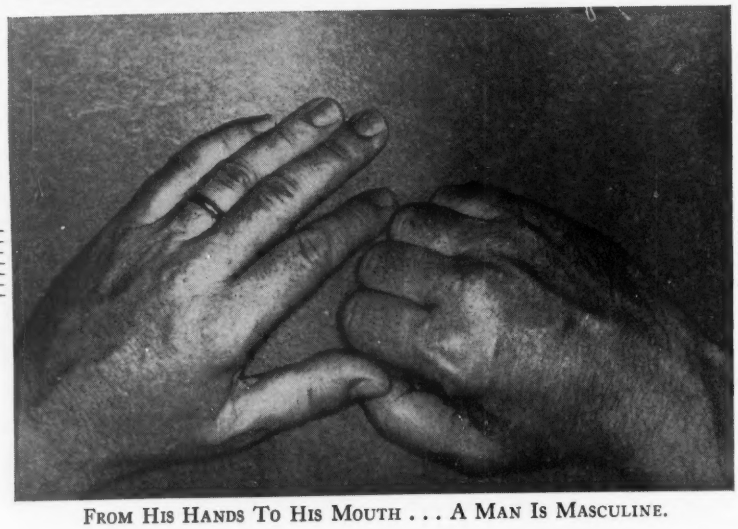
FEMININE

Before

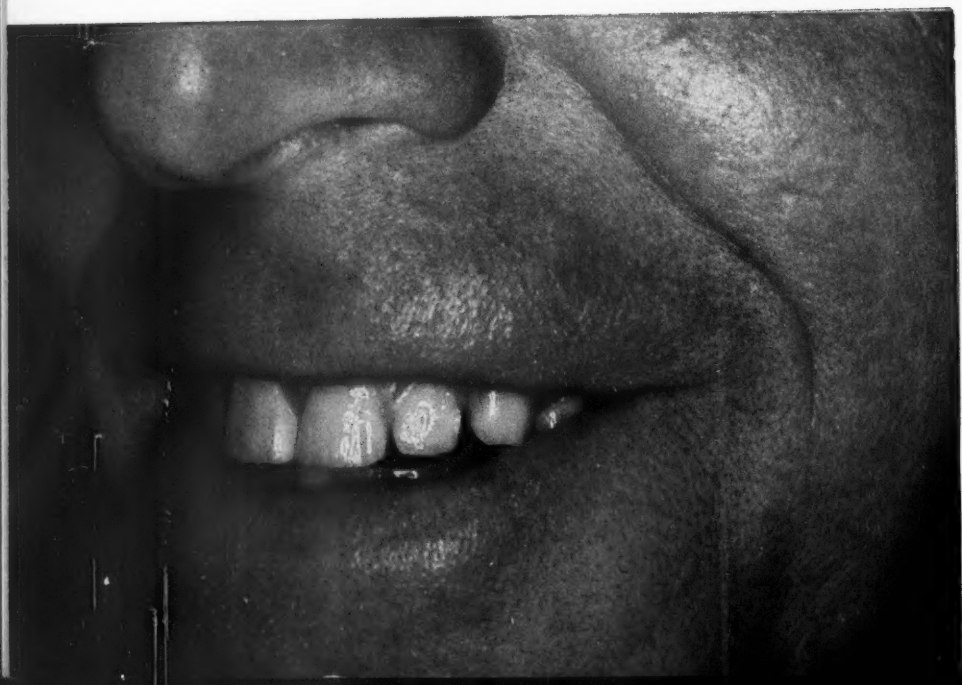
Conventional

and

Neuter Gender



From His Hands To His Mouth . . . A Man Is Masculine.



After

Dentogenic

and

Masculine

up nearly the total current concept of esthetic dental prosthetics when he wrote, "When the laterals are nearly as broad as the other front teeth, the set is said to have a strong or masculine appearance; when the laterals are narrower than average, the set is feminine or delicate." Reduced to the average concept, we found that "strong" generally meant "large" or "square," and delicate meant "rounded" or "smaller"; and in all concepts, the definition was on a flat plane, as you might draw the figure on a piece of paper on your desk. Thus, in the same two-dimensional plane we might differentiate a man or a woman, but we have not done a whole job.

Consider for a moment the photographs which appear in the color illustrations. Just what do they depict? What *all* do they depict? In the first place, they are photographs of two pairs of hands—human hands. But beyond that, they are utterly distinctive. In the first illustration is a photograph of the hands of a woman. The next page, just as indisputably, shows the hands of a man. There is no dispute as to the sex of the subjects of these photographs in spite of the fact that all that you see are the hands.

Just what are these photographs of hands doing in a magazine dedicated to prosthetic dentistry? Just this: just as there is a three-dimensional positive concept of masculinity or femininity in those two photographs of a man's and a woman's hands, so *should* there be an equally complementary appearance to the dentures either one should wear. See the "before" and "after" illustrations of a feminine mouth and a masculine mouth. In other words, "A woman is a woman from her finger tips to her smile," and "A man is man from his fists to his smile." But how often are the smiles of either sex completely neuterized by the usual dentures.

The purely mechanical and mathematical approach to tooth selection is largely responsible for the neuter gender "denture-look." We have studiously learned the "bizygomatic breadth." We have learned from anthropologists the precise dimensions in millimeters which characterize the central and lateral incisors and cuspids in *Homo sapiens* from the Neanderthal man to the contemporary Caucasian, and as a result we have been putting into people's mouths just such geometrically correct dentures as will accurately identify them chronologically to some distant anthropologist, but which currently give them very little pride and pleasure while they wear the dentures here on earth.

PSYCHOLOGIC EFFECTS

It is safe to say that no one contemplates with pleasure becoming edentulous and acquiring artificial dentures. Yet this need not be entirely so. There are many people with faulty and painful natural dentitions for whom prosthetic dentures could be both a relief and an improvement in physical appearance. By dentogenic restorations, many human interest developments have come to light among the practices of dentists who have helped bring dentogenics about.

A human interest story was presented at an alumni meeting of the University of California College of Dentistry in January of this year. A group of dentists,

while presenting an essay on the sex, personality and age factors in esthetics, introduced a young man for whom a dentogenic restoration had been created. What the audience did not know until after the lecture was over, and the patient himself sat down at a table to be interviewed by the attending dentists, was that this young man represented something far more than the usual recipient of a dental restoration. Affable, pleasant, and self-assured, this 24-year-old man calmly told the men at that table, that only recently, he had spent seven months in a mental hospital as a schizophrenic. He was sure now, in his own mind, that his remarkable recovery was due in no small part to the confidence and self-respect which his dentogenic restoration had given him. He had suffered through his youth being ashamed of his smile, and not until he realized that he could for the first time be proud of that smile had he begun to wonder how much of his earlier difficulties were traceable to his mouth and his teeth. The dentists disclaimed far more than the patient claimed for their work, but the definite contribution to the young man's present well-being could not be overlooked by anyone who saw and heard him.

Fortunately, examples of extreme psychologic problems, such as this, are rare; but this story might well be worth remembering if only to prod the dentist's awareness of the fact that *every* patient who comes to him with a dental problem is at the same time harboring a mental problem of a greater or less intensity. Consider, for a moment, that all too familiar plea, "Doctor, can you replace every tooth in my mouth just exactly as it is now?" Instantly we are alerted to a psychologic disturbance, but generally we are inclined to comply with this request even so far as to repeat some of Nature's esthetic errors.

Dentogenics seeks to face the issue squarely. Certainly, we could duplicate appearance, but more often we can go beyond duplication and actually improve appearance. The basic, unspoken statements in our patient's question are these: "Doctor, I don't want to suddenly look older," and "Doctor, I don't want to be changed by the 'denture look'."

By applying to the individual the SPA factors, by considering Sex, Personality, and Age, we eliminate the first objection immediately. With a careful explanation, in front of a mirror, of what we intend to do dentogenically for the patient, we can overcome the "change" fear by offering definite improvement. It is at this point in the contemplation of a prosthetic denture that we face a psychologic fact for which there is no mathematical equation to provide an answer. We must tell the patient that everyone notices change before he notices improvement. The reaction is the same whether it is in regard to a new hat, a new suit, a new hair-do, or new glasses. Anyone changing any of those things is certain first to be greeted with, "Oh, you look different," even though the comment may immediately be followed with, "That certainly is becoming to you." With improvement assured, the patient can face "change" with aplomb and confidence. Certainly, it is not as simple as these few overgeneralized lines may indicate, but the point should be clear. The importance of dental esthetics has been underestimated and vaguely conceived by dentists.

THE PERSONALITY SPECTRUM

Among the dentists attending the seminars at the Swissedent Foundation, the factors depicting sex and age in tooth form have been the more readily comprehended. Personality interpretation has appeared to be a bit more difficult to grasp. To provide a working tool for dentists as regards the personality factor in dentogenic restorations, we have conceived the "personality spectrum." Here the dentist is asked to imagine the broad span of personalities with whom he comes in contact, in the frame of the light spectrum, as refracted through a prism. We have then the familiar color-band of vertical rainbow hues extending from red to violet. If we consider, for a moment, three different people whom we know, and decide for ourselves just where we would place each of these three personalities in the color band, we would invariably find that they actually fitted into three different areas. The rugged, male extrovert could only fit into the bold, red end of the spectrum; the shrinking violet type female could only belong at the right end of the scale; and the medium, normal type, male or female, would fit somewhere in between. Dentogenically, the spectrum of human personalities need not be quite so complex. We have found, first, that the human personalities with which we deal conveniently fall into three general categories; the vigorous type (red to purple band), the medium type (orange to yellow band), the delicate type (green to violet band). Abandoning color, then, in the strict personality spectrum, let us envision our spectrum as composed of bold long black strokes on the left, descending by narrowed, shorter strokes toward the right until we have short delicate lines where white predominates. The 15 per cent of our patients who probably fit the bold black area we shall find are vigorous males. The opposite 5 per cent who, we estimate, fit the delicate area are generally females. In the broad spectrum between we have the medium, pleasant-type personality, composed of both sexes. In other words, 80 per cent of our patients fall into the medium personality group, but the work of the dentogenic-minded dentist does not end there. True, he may quickly and roughly classify his patient, but inside the broad 80 per cent of the spectrum there lie many things to be considered. First, the patient is a male or a female, which was established upon sight. Next, this same medium-type personality leans toward one end of the spectrum or the other, and this is established only upon conversation and observation. It is not necessary to frame the personality spectrum upon the wall of one's private office, and meticulously seat the patient in front of it during an interview to establish his or her place in the scale. But it *is* convenient to bear the personality spectrum in mind during a discussion and pre-select the area. As often as not, the patient's personality classification shifts either to the right or left, in subsequent interviews, but that is to the dentist's credit. The more he knows about his patient, the better dentogenic restoration he will produce. Dentogenics, in the end, is the application of artistry to professional skill and mechanical proficiency.

DENTOGENIC INTERPRETATION

Taken all in all, the dentogenic interpretation is not as frightening as it may first sound: Sex, Personality, and Age. There are still only the two sexes, im-

mediately identifiable upon sight, but it is important that they be identified in the smile just as they are so positively identified in dress, hair style, and all other visible features. Age can be easily separated into young, middle, or elderly, and no patient in any group deserves the tooth form or tooth color of either of the other classifications. Personality is a bit more complex, but, again, a general matter of three: vigorous, medium, or delicate, with the gradations emanating from the middle, medium pleasant-type personality toward either the bold or delicate areas of the "personality spectrum."

THE DENTURE BASE

Except for the enthusiasm and dedicated interest of many of the dentists who have become associated with the Swissedent Foundation, dentogenics would have stopped at this point. But it did not. We were constantly reminded that the SPA factors did not include patient comfort, despite what had been done for appearance. All of our conclusions about the vital factors, including arrangement, shape, and color of teeth in a dentogenic denture, had ignored the consideration of the plastic base itself. How could we aspire to the fulfillment of the term esthetic in prosthetic dentures and at the same time overlook the existing shortcomings in the conventional denture base? By common practice, the denture base is a smooth and shiny surface with crevice-shaped repositories for food particles which cling after every meal to form bacterial nests which are not only unsightly, but unsanitary, and if left for long, odoriferous.

Again, with the Sex, Personality, and Age factors firmly in mind, and with the latitude already achieved by assymetric spacing and arrangement of the teeth, we studied the possible unconventional treatment of the visible plastic base. First, by slightly convexing, instead of flattening or concaving the acrylic resin between the teeth, we found that we were able to achieve two results. One, we eliminated the standard crevice, or bacterial repository, and second, we heightened the natural appearance of the artificial gum. By lowering the visible papillae we found we were able to heighten the natural effect still further. Up to this point, the accepted virtues of a smooth plastic surface were adopted. As a further development of the acrylic resin base, we stippled the labial and buccal surfaces of the denture base with a No. ½ round eccentric bur. The result was amazing and gratifying beyond all hope and expectation. The accepted "difficult" foods, such as bits of lettuce, corn skins, and apple rinds could be swept off the base with a flick of the tongue as easily as breathing. It was a simple application of high-school physics; a rubber suction cup will stick tenaciously to a smooth surface; it is impossible to make the same cup adhere to concrete.

This, all too briefly, is an introduction to dentogenics. In subsequent articles we hope to bring you more specific details with an article devoted to the discussion of each of the dentogenic principles. It is a new field, a growing field, and everyone who joins it contributes to it, for his own and his patients' good.

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HOW THE SCIENCE OF ESTHETIC TOOTH-FORM SELECTION WAS MADE EASY

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IN HIS INTERESTING article entitled "Selecting the Anterior Tooth Mold," Young[1] writes, "Present-day theory seems to postulate that there is little data associated with the edentulous face to indicate the tooth form most suitable for it."

Such a mental attitude on our part is seriously unfortunate for our patients and for us. There is as much data as there ever was. No face that has neither form-supporting teeth nor occlusion rims in place has ever afforded data for a pleasing restoration. The same face, when restored to its most pleasing form and size with occlusion rims, affords much of the data necessary for the most pleasing restoration possible to that face. The rest of the data is readily available.

The story of how it was made possible for those of us who had no artistic training, and only ordinary artistic perception, to create pleasing or beautiful restorations for edentulous patients is a part of the story of our professional evolution. That evolution continued for many years, and reached a high point in 1914. We should all know this story. It is a part of our background. It can be an important factor in our success. Let us analyze and summarize it so we can apply it.

SOME CONDITIONS IN PRACTICE PRIOR TO 1914

There were no lifelike artificial anterior teeth. There were hundreds of molds which had been carved as copies of pleasing natural teeth. They were carved by skilled artisans, most of whom were not dentists. The outline forms and the labial surfaces had been made mechanically unlifelike. They reflected light and color in unnatural and unpleasing ways. Each mold stood alone, unrelated in form or size to any other mold, or any form of face.

There was no clearly understandable theory of face-form-tooth-form harmony to guide form selection. The author asked a dentist, a natural artist who was famous with the public for the beauty of his restorations, how he made dentures so beautiful. He replied, "I don't know. I grind the teeth until I like their looks." That was explanatory but it did not teach the author how to do it.

We who went to dental depots to select molds by what Young calls "hunt and pick" tried to select by the temperamental theory. Many dentists left mold selections to tooth clerks and technicians who never saw the patients. Some dentists selected three or four molds they liked, and used them for all patients. Some dentists used only one mold for all patients. Denture restorations were at a low level in public opinion.

Received for publication March 4, 1955.

WHAT WAS THE TEMPERAMENTAL THEORY?

It was a theory of the fluids of the body, especially the blood, the phlegm, and the bile. It was conceived in the fifth century, B.C., and was used continuously by the medical profession in diagnosis and treatment until the nineteenth cnetury, when it gave way to demonstrable science.

The first temperament, the sanguine, was evidently the temperament of good health. There was plenty of red blood, a red complexion, large body, strong musculature, and vigorous action. The second temperament, the phlegmatic, showed a physical decline because of a dominance of phlegm, which is a form of mucus, in the blood. The body was slight, the complexion was fair, the tissues were soft, the actions were gentle. The third temperament, the choleric or nervous, was the result of a dominance of yellow bile in the blood. The body structures were small and finely textured. The disposition was irritable.

Young tells us that in 1872, when the temperamental theory was fading out of medicine, White[2] reached over into that theory and suggested that the temperaments called for similarity of form in faces and teeth. This may have been the introduction of the temperamental theory into dentistry. It was to stay with us more than forty years. Temperamental forms of teeth were produced as "named sets," and helped to make tooth-form selection temporarily easier.

In dentistry, the temperamental theory was not defined or illustrated in any generally accepted and authoritative way. Only rarely could two dentists agree on exactly what the theory meant, what it taught, and what it required. Something of its intangible quality is shown by the photographs in Fig. 1.

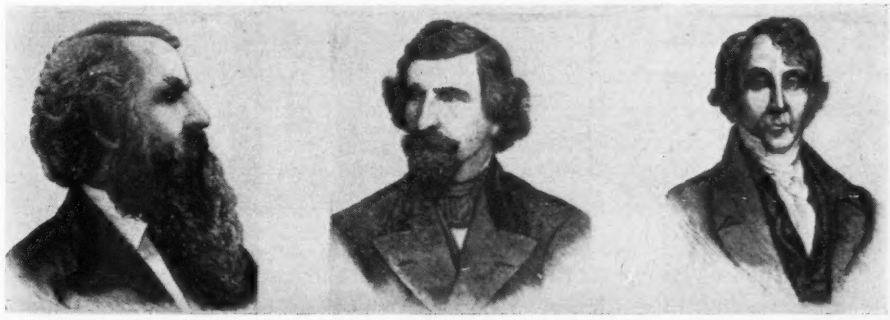


Fig. 1.—Basic temperamental face forms. A famous professor in a prominent dental college published these pictures as basic temperamental face forms, to be used as guides in the classification of face forms and in the selection of tooth forms. He classified them, left to right, as sanguine, bilious, and nervous.

Some dentists stepped mentally outside of the temperamental theory. Young writes that, in 1887, Hall[3] discovered that there are three typal forms in natural teeth. He named them ovoid, tapering, and square. He did not interest a manufacturer in his discovery, and without the aid of a manufacturer to produce and introduce the teeth, his discovery could have no practicable value. It was forgotten. Twenty-five years later, the forms were to be rediscovered by another dentist, and a manufacturer was to help give them great value.

In 1903, Berry[4] discovered he did not need blood, phlegm, and bile to account for face forms and tooth forms, and a law of harmony. Faces and teeth were physical structures he could see, study, and use. He studied the face of each operative patient who had a complete natural dentition, and compared the outline form of the upper central incisors with the outline form of the face in repose. In the most pleasing faces, the outline forms were alike. The tooth forms were inverted face forms. In proportion as the tooth forms were not like the face forms, the facial appearance was not pleasing when the teeth were exposed. This knowledge guided his artificial tooth-form selection.

He gave a clinic with his new knowledge in 1904 and published it in 1906. In the published story, he did not tell us that he rebuilt edentulous faces to proper form and size with occlusion rims, but he must have done so because he drew an outline picture of each face when it was ready for tooth-form selection, took the drawing to a dental depot, and hunted among the miscellaneous and unrelated forms until he found the form most like his drawing of the moment. The results were probably much more pleasing than they would otherwise have been, but the technique was too difficult and time-consuming for most practices.

THE BEGINNING OF A REVOLUTION IN OUR ESTHETIC STORY

In 1900, an American dentist, J. Leon Williams, had an excellent practice in London, England. He was the most famous dentist of his time because of his achievements in dental histology, bacteriology, and crown and bridgework. He was a member of several famous societies and had been elected to honorary membership in dental societies in more than twenty countries. He was also an artist by natural endowment and skillful training.

In 1895, he became very unhappy over the appearance of his denture restorations because of the mechanical unnaturalness of the tooth forms. There could be no lifelike restorations until he could get lifelike artificial teeth.

He besought the English dental societies to persuade the manufacturers to make lifelike teeth. The members of the societies were living in continuous fee competition. They were not interested in tooth forms and did not reply to Williams' appeal.

One of the two largest tooth manufacturers in the world was located in London. Williams presented to the board of directors the benefits that would accrue from lifelike teeth. The board heard him courteously and replied that the dentists who bought most of its teeth were satisfied with them. The company could not face the great financial risk and the risk to prestige that would follow such an undertaking. The answer was "No."

The other of the two greatest manufacturers was in America. Williams' scientific work, in previous years, had brought him into active association with this company. He knew the officers. In 1909, he came to America and presented his plans to the company. The answer was the same as that of the English company. His two greatest hopes had failed.

But all hope was not lost. He knew of another company to which he might present this great opportunity. It was a younger and smaller company.* It was

*The Dentists' Supply Company.

earning professional favor by rendering new forms of service. In 1906, it had offered the author, who had just finished six years of successful practice, an opportunity to become its Director of Professional Research, with the thought of possible further extensions of service. The offer was accepted. After about a year of study of the general situation, the Company published a new technique in the esthetic field that, for the first time, made it easy for the dentist to find, among the miscellaneous molds of the time, the size and form of teeth that would be most pleasing in the patient's face.

In this technique, the dentist was to build occlusion rims of proper height and form. With the patient's lips at rest, he was to mark, on the upper occlusion rim, the locations of the corners of the mouth. Then he would have the patient raise the upper lip as far as was comfortable, and would mark a high lip line on the occlusion rim. He would depress the lower lip and mark a lower lip line on the lower occlusion rim. After removing the occlusion rims from the mouth, he would mark, on both sides of the rims, the locations of the distal sides of the second molar teeth (Fig. 2).

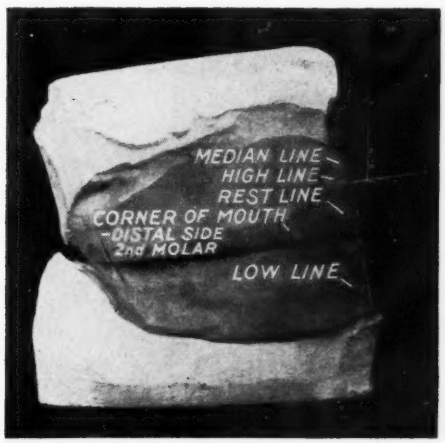
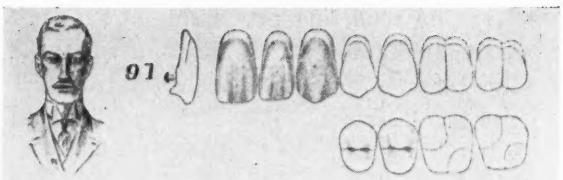


Fig. 2.—Informative markings on the occlusion rims.

The distances between the markings on the occlusion rims were to be measured in millimeters. A flexible millimeter rule that would bend around the occlusion rim had been invented, and was offered free to every dentist.

The markings at the corners of the mouth located the distal sides of the upper cuspids. The distance between the markings, in millimeters, was the width of the most desirable anterior teeth for that patient. The distance from the occlusal surface of the occlusion rim to the high lip line was the length of the labial surfaces of the upper central incisors which that patient needed for a pleasing appearance. The distance from the mark at the distal of one second molar, around the rim to the other similar mark, was the width, in millimeters, of the complete set of teeth which that patient should have. The dentist could now know, without leaving the office, what size of teeth each patient needed.



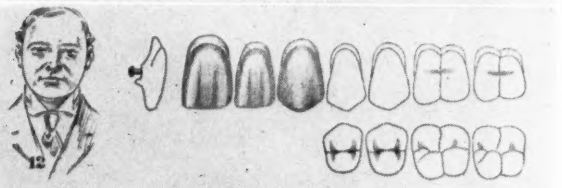
Mould 91. **Dimensions of centrals: length 11 mm., width 6¾ mm., bite 2 mm., shut 3 mm., ridge-lap 6 mm. Approximate width 6 anteriors, 42 to 43 mm. Approximate width full 14, 99. Combined bite and shut of central, 5½ mm. Required vertical space second molar, 5½ mm. Medium deep collar.**

An extremely short bite mould. The outline of the central is long and narrow, with medium wide neck, and the distal angle considerably rounded. The laterals and cuspids are in excellent proportion to the centrals. The anterior teeth present flat labial surfaces.

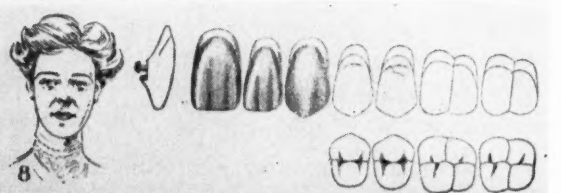
The bicuspids and molars are of medium size, with short cusps and well defined sulci.

Anteriors from this mould combine well with posteriors from moulds 19–51–4–28–65 to form 14's. Plain lower mould 91 was made especially to articulate with this mould. This mould articulates well with lower moulds 91–2–7–17 to form 28's.

Indications. For faces of medium length but less than medium width, and tapering gently to chins of medium width. For cases where the ridge is long in proportion to the lip, so that the labio-incisal angle of bite comes only 5½ mm. below the surface of the ridge. Valuable in those cases where the lip is raised high in laughing, since if the pins are set on the ridge, this tooth will cover a space 10 mm. long. The form of ridge-lap leaves quite a bulk to labial, which is sometimes desirable.



Mould 12. **Dimensions of upper centrals: length 11 mm., width 7⅜ mm., bite 3½ mm., shut 2½ mm., ridge-lap 5 mm. Approximate width of 6 anteriors, 46 mm. Approximate width of full 14, 106 to 107 mm. Combined bite and shut of central, 6½ mm. Required vertical space second molar, 5½ mm. Collar.**



Mould 8. **Dimensions of centrals: length 12 mm., width 7½ mm., bite 3½ mm., shut 3½ mm., ridge-lap 5 mm. Approximate width 6 anteriors, 45 mm. Approximate width full 14, 106 mm. Combined bite and shut of central, 7½ mm. Required vertical space second molar, 6 mm. Collar.**

Fig. 3.—Complete technical information and the beginning of esthetic information. Esthetic information like that given for Mould 91 was given for Moulds 12 and 8. It is omitted here to conserve space.

Many molds of teeth were measured in millimeters. The measurements included the width and length of the upper central incisors, the width of the six anterior teeth, the vertical separation of the jaws, and the approximate width of the full set of teeth. Every step of the new technique was illustrated and published in 1908.[5]

The esthetics of the different tooth forms had been given as much attention as the knowledge of the time made possible. A picture of each tooth form was published with such description of its form-characteristics as had never been known. There were suggestions as to the form of face with which each mold might harmonize—a new form of esthetic instruction. By way of suggesting how dentists might well learn to think about face-form-tooth-form harmony, pictures of a few faces were placed along side the pictures of molds that harmonized with them (Fig. 3).

There were practical results. The selection of tooth sizes and forms began to be scientific, easier, and faster. The conception of esthetics had been strengthened a little. The dentist could learn more about the mold of teeth he needed, in a few minutes, than he had been able to learn in any other way.

The psychology of progressively constructive service was the psychology Dr. Williams was seeking. The Company welcomed his presentation and gave it careful consideration. Then it replied that his project was so strictly professional that it did not feel competent to render a decision. It was so big that it would require of the manufacturer who cooperated a large investment of time and money. If the profession did not accept the new teeth, the manufacturer would suffer a serious loss in money and prestige. If Williams could secure a satisfying professional approval of his project, the Company would cooperate with him, would produce and introduce the teeth, and would risk the loss.*

Williams presented his project before The National Dental Association, now The American Dental Association, in July, 1910, and before other important dental societies soon afterward. Each society voted unanimously an unqualified approval of his plans, and asked the manufacturer who cooperated with him for the teeth as soon as possible. The author became Williams' associate in making the project practicable.

A SURPRISE CONFRONTS WILLIAMS

When Williams began the detailed study necessary for the production of lifelike tooth forms, he came face to face with a great surprise. He had supposed manufacturers knew their teeth were not lifelike, knew why they were not lifelike, and knew how to make them lifelike. He found they had no conception of the unlifelikeness, or of what would make them lifelike. They had no conception of any system of tooth forms that would make esthetic form-selection, by dentists, easy

*A slight conception of the size of the possible loss can be formed when it is known that, after two years of labor and expense in making molds and producing teeth, the Company had to stock American dental depots with 8,000,000 teeth, at its own expense and risk, before the profession could buy the teeth, and either approve or disapprove.

and rapid. If he was to produce lifelike forms, he must find out what would make forms lifelike, just what to do, and how to do it. Then he must do it. If there was to be a system of teeth, he alone must form it. He returned to London, and devoted every hour he could spare from practice to the solution of these problems.

RESOURCES FOR STUDY AND MANNER OF STUDY

Williams was to study tooth forms more analytically than he had ever studied them. His resources were excellent. He had many extracted teeth and more were sent to him after his addresses. Dr. H. E. Friesell, Dean of The School of Dentistry, University of Pittsburgh, sent him nearly a bushel of teeth in good condition for study, and 20 sets of fine, natural anterior teeth. They were to prove to be almost invaluable. Williams was admitted to unlimited study in The Museum of The Royal College of Surgeons, in London, which had a wonderful collection of skulls from many parts of the world, most of them with carefully retained teeth. He had the habit of unceasing study.

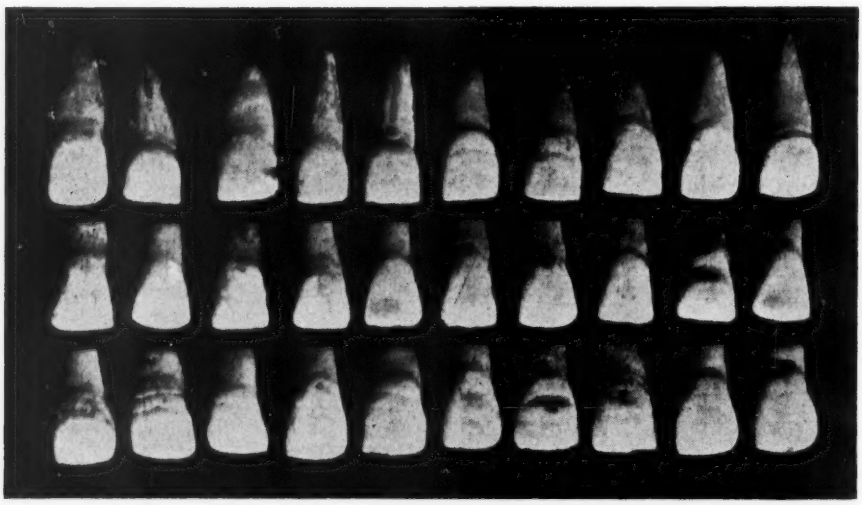


Fig. 4.—Typal and nearly typal forms in natural teeth. First row, Class I. The perfect typal form is not frequently seen in the square type. It is best shown here in Nos. 3, 4, 5, and 6. Second row, Class II. The perfect typal form is much more frequently seen in the tapering type than in either of the other types. Third row, Class III. The perfect typal ovoid form is rare. The central incisors are marked by a distinguishing double curve on the distal surfaces. The curve is faintly seen in No. 4, and more strongly in Nos. 5 and 10.

He knew the temperamental theory thoroughly. He believed it to be as frail as a house of cards, and as empty as a soap bubble. He began by intensive study of the characteristics of upper central and lateral incisors, and cuspids. Since he found the central incisors most characteristic and helpful, he studied them for basic information (Fig. 4).

After about a year of study, he discovered that there are three typal forms of anterior teeth, meaning by "typal" the forms from which all other forms derive. He found these forms in every one of the many races of man that showed even

a dozen skulls, in The Museum, with the upper anterior teeth retained. He found them also in the anthropoid apes, which antedate man by millions of years (Fig. 5). He wrote, "When I saw clearly that these three forms of teeth existed in all races, I knew I had got nature's secret of design in human teeth."

He had discovered more than how Nature had systematized anterior tooth forms. He had discovered also how Nature produced the innumerable nontypal forms. They were "combination forms," created by the inblending, into each typal form, of more or less of the elements of one or both of the other types. Tapering or ovoid or both were inblended into square. Square or ovoid or both were inblended into tapering. Square or tapering or both were inblended into ovoid. Many of the combination forms were more pleasing or beautiful than the typal forms. These discoveries suggested that we should follow, in artificial teeth, Nature's plan in natural teeth, so that the two systems could go forward harmoniously, side by side. Dentists would need the typal forms only rarely, the combination forms continuously.

Fig. 5.—Typal anterior tooth forms in orangutans.

THE FIRST SYSTEM OF ARTIFICIAL TOOTH FORMS

A mental picture of a helpful system of tooth forms had come intuitively into his mind. There should be three classes of tooth forms, each class dominated by one type. To start planning the system, he placed three natural typal teeth at his left, on his work table, one square, one tapering one ovoid. Then he took a large number of combination form central incisors, studied each tooth intently, and placed it beside the typal form that dominated it. He continued the placing until he had a long row in each type. Then he began a carefully comparative study of each tooth in each row, and rearranged them so that the slightly inblended teeth were near the typal forms at his left, and the other teeth graduated away to the greatly modified forms at his right.

By careful analyses, he reduced to six the number of combination forms in the square type, which he now thought of as Class I. He reduced to six the forms in the tapering type, which he now called Class II, and to four the number in the ovoid type, which he now called Class III. These 16 forms covered the range of

natural tooth forms much more helpfully and pleasingly than did the thousand or more miscellaneous molds in dental depots.

The forms were readily understandable as to their origins, could be easily memorized, and would help to make esthetic form-selection easy and pleasing. Then he selected lateral incisors and cuspids that harmonized with each of the central incisors, and formed complete sets of maxillary anterior teeth. He formed the sets of lower anterior teeth by the same kind of selection.

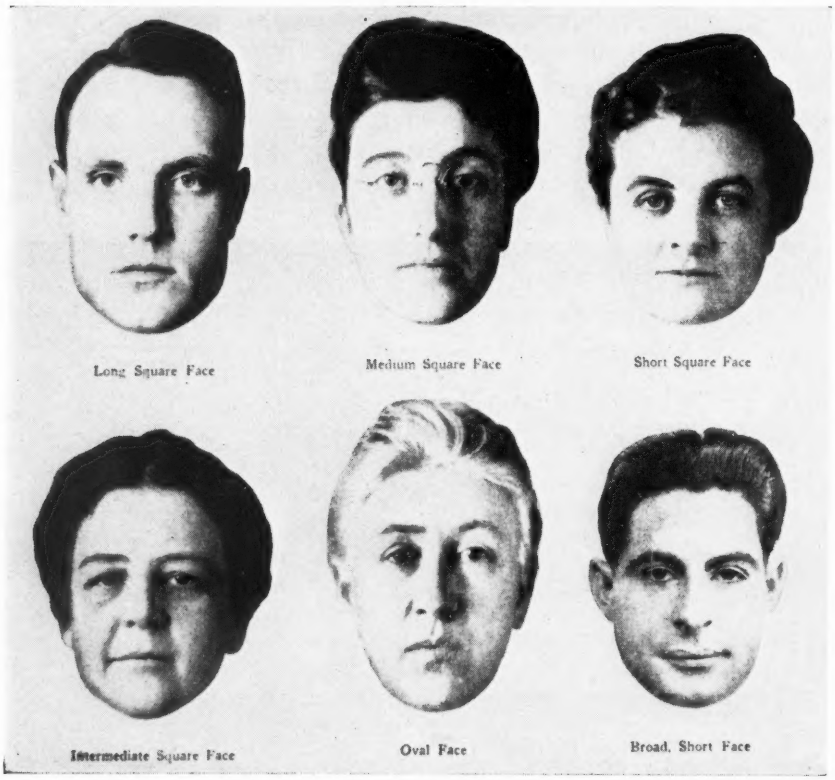


Fig. 6.—Class I of The Face-Form Guide. The Guide, in three sections, of which this is the first, showed photographs of 16 persons whose teeth were like the forms Williams had selected for the new system of teeth and whose face forms were like their tooth forms.

APPROACH TO THE FACE-FORM CLASSIFICATION

To get the mental pictures of face forms that he needed, Williams had to look at faces from directly in front. He looked at his operative patients in that way. On the street, he looked at hundreds of faces with new keenness. After a short time, he began to identify typal forms of faces, and to perceive that they were identical with the typal forms in teeth. One form had straight and parallel sides. Another had straight sides that converged downward. The third form was wide and heavily rounded in the lower half. So far as he knew, these face forms were

not a part of general dental knowledge. Here was the secret of face-form-tooth-form harmony, since the law would surely hold as well for combination forms as it had for the typal forms.

A little later he accepted the typal square and tapering forms Madam Schimmelpeinik had drawn for artists in 1815. There was no circle form of face, such as she had drawn. She had misinterpreted the ovoid form. He had diagnosed it and classified it as the third typal form.

For the continuation of his study, he needed facial pictures of persons whose natural teeth were of the same forms as the 16 forms he planned for the new system. He could not get such pictures taken as he needed them, and he had no facilities for taking them. To meet this need, the author, with the aid of Dr. Russell Wilford Tench and a highly skilled photographer, established a photograph gallery in New York, in 1912, and photographed many people whose natural dentitions covered the range of the 16 forms (Fig. 6).

Photographs of the faces were published in 1916.[6] They constituted a "Face-Form Guide," gave all dentists the benefits of the studies, and were active in the profession for many years. The pictures shortened the time required for tooth-form selection. When the dentist found the face-form picture most like the face of the patient of the moment, he could find, in the picture of the Mould Guide in the same book, the picture of the tooth form that would be most pleasing in that patient's face. It would be the same number, in the same class as the face.

TWO AUTHORITATIVE DEMONSTRATIONS

The photographs we took established the first factual proof of the exactness of the harmony of face forms and tooth forms in Nature's finest handiwork. There had long been strong belief in the existence of this harmony, and many expressions of the belief. But there had been no indisputable proof. Here was the proof. The photographs demonstrated also Williams' almost unbelievable skill in carving artificial tooth forms to harmonize with face forms (Fig. 7).

ON WHAT SHALL WE RELY?

Young[7] tells us, "Richey has projected that successful denture artists never rely upon analytical routines or stereotyped patterns of creations, but that their artistry is true artistry, based on emotion, mental imagery, and stored knowledge of the human face. The advice of old masters in the fine-arts field has consistently been to forget rule and regulation, for these give an artificiality and amateurish value to the product."

All that is probably true in the fine arts field where the artist has considerable freedom. In esthetic denture restorations, the dentist does not have that freedom. He is not constructing something new and unfettered. He is replacing a visible and very important lost part. The rebuilt face is the form to which the part should conform. It is an individual form. There is none other exactly like it. Conformity is essential to pleasingness and beauty. The information and illustrations Williams developed for making conformity easily possible, were not rules and

regulations. They were visible and usable expressions of what has just been referred to as "stored knowledge of the human face." Temperamental dentistry was made up largely of freedom, emotion, and mental imagery. It was deficient in stored knowledge of the face. Where is it today?

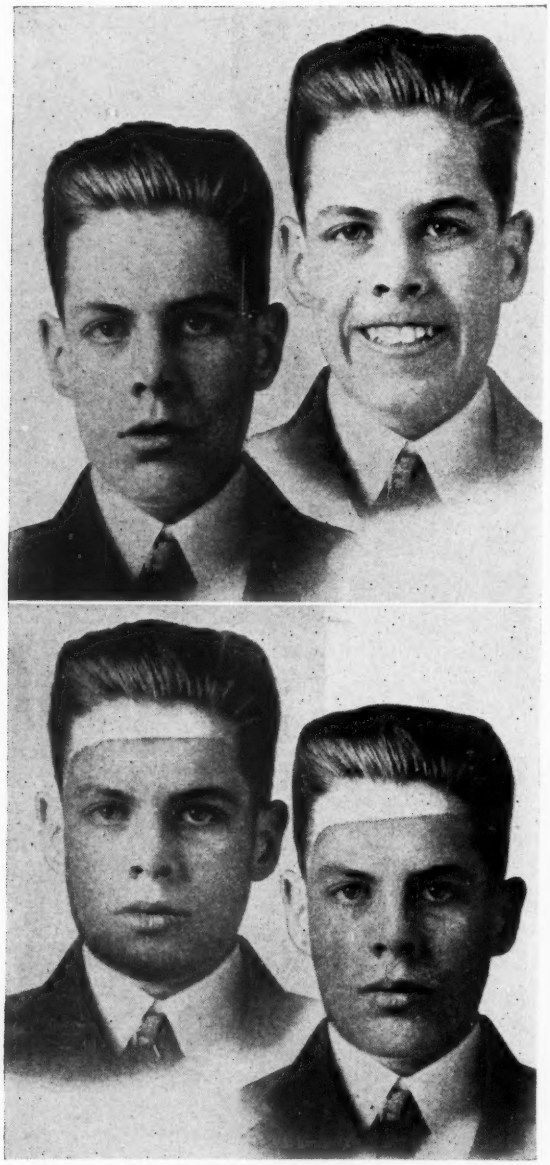


Fig. 7.—The first indisputable proof of face-form-tooth-form harmony in two parts. Above, the face form in repose and the upper central incisors fully exposed. Below, at the left, the photograph of one of the central incisors photographed onto the photograph of the face in repose. Identity of face form and tooth form. At the right, the photograph of the central incisor Williams carved for this form of face, photographed onto the photograph of the face, in the same way with the same identity of form. Photographed in 1914, published in 1916.

TWO CONCEPTIONS OF DENTURE ESTHETICS WITH UNLIKE RESULTS

Young emphasizes two words or terms in connection with the esthetics of tooth-form selection which it may be well for us to analyze and employ. They are "emotions" and "mental imagery."

The medical dictionary defines our emotions as our feelings when stimulated by some external cause such as sight, hearing, thought, or contact. The emotions are not intellectual. They do not think, plan, execute, or teach. They are pleased by harmonies, disturbed by disharmonies. Mental imagery is the formation of pictures or objectives in the intellect. It thinks, plans, inspires execution, and teaches.

In 1912, the author knew the dentist of whose story a little was told earlier in this article. We shall call him Dr. A. He is an excellent example of the influence of strong emotions in the selection of tooth forms, and was famous for the beauty of his restorations. He followed the usual technique for impressions, cast formation, and the formation of wax denture bases. Instead of setting a mold of teeth on the bases, he built occlusion rims on them, made a maxillomandibular registration, and then painstakingly formed their labial surfaces in such a way as to rebuild the face to the most pleasing form possible to it. He had more than average artistic ability and rebuilt faces well.

Then he selected a mold of teeth a little longer than the patient required, asked the patient to retain the denture bases in the mouth, and ground the upper central incisors to the outline forms he liked for that patient. He set the central incisors into the upper occlusion rims, removed the baseplates from the mouth, and, later, ground the lateral incisors and cuspids to harmony of form with the central incisors.

He was well rewarded for his skill. He had the esteem of his patients, the admiration of other dentists, the satisfaction of skillful service well rendered, and financial success through high fees willingly paid.

When Dr. A was questioned, he replied that he did not know how he made dentures beautiful. He ground the teeth until he liked their looks. That satisfied his artistic hunger and warmed his emotions. He did not recognize that when he rebuilt the face form with occlusion rims, the rebuilt form of the face made a definite impression on his memory. When he ground the outline form of the teeth, he unconsciously ground them to be like his memory of the face form. By so doing, he unknowingly conformed to one of Nature's fundamentals of denture beauty, that the form of the upper central incisors should be like the form of the face in repose. His emotional pleasure came after he did the grinding, but it did not enable him to teach others how to do it.

What is mental imagery? We repeat that it is the formation in the intellect, not in the emotions, of some desirable objective, perhaps something material, perhaps greater knowledge and skill, also in the taking of the mental steps by which the objective can be attained. There was great need in the field of denture esthetics for more and better mental imagery, because it could be understood and taught as the emotions could not. Except for some "named sets" of temperamental teeth made in the 1880's, little had been done to improve this phase of denture service for many years. Denture service and dentists were at a low level in public opinion.

FORWARD STEPS IN MENTAL IMAGERY

Williams was probably the most skillful artist who ever became a dentist. His skill was partly due to high artistic endowment, and partly to skillful training.* When, in 1895, he became unhappy because of the unpleasing appearance of his denture restorations, he applied to this problem in esthetics the same kind of research that made him famous as a research scientist in bacteriology and histology.

Working alone, without having heard of any others who had studied, or were studying the esthetic selection of anterior teeth, he made two important discoveries. He discovered the typal and combination forms in faces and teeth. He discovered Nature's law of the face-form-tooth-form harmony.

To make these discoveries practicable to all dentists, he made two inventions. He invented a system of artificial anterior tooth forms that covered a wide range of forms and was easily adaptable to individual requirements. To facilitate the selection of the form most desirable for any face, he invented the Face-Form Guide and a technique that made esthetic tooth-form selection easy, rapid, and more successful for dentists generally than form selection had ever been.

When no one could be found who could carve the pattern teeth that would give the new teeth the characters they should have, he applied his already highly developed skill in sculpture and, by eighteen months of almost continuous effort, carved the patterns for 16 forms of teeth, in 57 molds, a total of 675 teeth. This was mental imagery at its best.

Williams presented the new science and the new tooth forms, in December, 1913, and March, 1914, before two very large meetings which had been especially arranged for the presentation by the First and Second District Dental Societies of New York City. Both the science and teeth were eagerly welcomed. The science gradually replaced the temperamental theory, as it had done in medicine.

As the application of the science expanded, its benefits became profession-wide, then world-wide. Denture service and dentists rose to a higher plane in public esteem than had ever been known. The science was a part of the science of life. We can go forward in its application as long as we practice.

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*He was once threatened with tuberculosis as a result of overwork. His physician ordered him away from the office for two years. He spent much of that time studying painting under famous teachers. His paintings were shown in art exhibits and were praised.

PSYCHOSOMATIC ASPECTS OF PROSTHODONTICS

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PERHAPS A MORE APPROPRIATE title would be "The Fundamental Principles of the Psychosomatic Approach in Prosthodontics." This thought implies the existing knowledge concerning the influence of psychologic factors upon the function of the body and its disturbances. Accordingly, an attempt will be made to present some material on the psychosomatic aspects, including approaches, of prosthodontics.

Admittedly,[1] dentistry has made outstanding strides in the twentieth century, especially in the second quarter of this century. This progress in the mechanics of the profession is so conspicuous that a great segment of the people is likely to look upon the dentist as essentially mechanical minded. In the fields of surgery and prosthesis, spectacular strides also have been made; still, here we detect pitfalls even with our increased knowledge of pathology.

Too frequently the application of the knowledge of pathology, therapeutics, etc., falls short of the anticipated goal according to the books. Invariably, attempts have been made to explain these exceptions even with the full realization they are too numerous to explain. How many teeth were sacrificed no longer than a decade ago without benefit to individuals, many of whom still remained afflicted with pain, iritis, and rheumatism! In addition, they experienced progressive, accumulative conditions incident to disturbance in the disorganization of the occlusion.

The past twenty years have shown astounding, and what might be referred to as revolutionary, changes in the study of and clinical application to psychology, psychiatry, psychosomatic medicine, and psychodontia.[2]

McCortney states, "Hysterical systems are unique creations of the patient invented by his unconscious for the expression of his particular repressed psychological content." Ego frustration of long-standing unsatisfied needs may be converted into so-called headache, transient "black-out," tachycardia, peptic ulcers, colitis; or tissues around the mouth may be used as a means of such expression. Thumb-sucking, nail-biting, excessive gum-chewing, unilateral masticating, clenching, bruxism, thrusting tongue against natural or artificial teeth, etc., may be the hysterical expressions of unfulfilled needs.

Pain—vague pains in hysterical patients—of a nonspecific character may appear and radiate through the mouth along nonanatomic or confused neurologic lines and mistakingly be assumed to be due to dental pathology. Teeth are extracted or

Read before the Academy of Denture Prosthetics, New York, N. Y., May 5, 1955.
Received for publication May 5, 1955.

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sinuses surgically explored when a careful analysis of the pain will reveal that it is atypical neuralgia due to "focal conflict" rather than focal infection. A search of the life situations rather than a search for foci of infection is the proper approach. Most of these individuals experience associated symptoms including complaints referred to the head and neck, such as severe headaches, migraine, supraorbital pain, tension, soreness of scalp and posterior neck. This is particularly true in cases of chronic anxiety with hyperesthesia and hyperexcitability, especially found in the adolescent and the older groups of individuals. Likewise, definite evidence of vasomotor or autonomic instability is associated with this type of person. The most frequent and annoying associated symptom is hyperhidrosis. The palmar sweat test readily confirms this observation and may not only be employed for confirmatory diagnosis, but also aids materially in assisting the patient to develop initially an insight into his primary problem—that of an emotional disturbance. Malino[3] has demonstrated, in what he calls "symptoms specificity," that a rise in forehead tension is specifically susceptible to activation by stressful experience in life situations. Furthermore, he deduces that although more than one patient may have a similar tensional symptom, the temporal aspects of the chain of physiologic events leading to elicitation and subsidence of the symptom may be quite different from case to case. For example, some women during menopause give a history of sexual frigidity along with acute flare-ups of burning tongue, or flashes of pain in the palate or cheeks. (In those instances where these symptoms appear in men, there is evidence of impotence in their histories.) Such female patients will manifest fear of pain, will offer resistance to the attentions of the dentist, and will reject care by identifying with a parent who has expressed similar resistance to dental care. Furthermore, the resistance may take the form of masochistic demands for extractions with underlying hostility to the surgery and resentment of the fee required by the prosthodontist.

Very frequently a fear of masturbation or rape will constitute the underlying thought sequences that awaken tension in the dental situation, and the prosthodontist's fingers may stimulate erotic feelings through the mouth.

A white woman, aged 22 years, unmarried, the third child in her family, was presented with the need of complete dentures after a year away from home, during which time she had three appointments weekly with the prosthodontist. She was hospitalized for malnutrition and psychotherapy for an additional nine months in preparation for successful invasion of the mouth. The diagnosis made with Rorschach confirmation was: hysterical reaction superimposed on an extremely oral-dependent personality. Incidentally, the psychotherapy that made it possible for the prosthodontist to construct acceptable dentures was also responsible for her subsequent marriage. To state it in other words, the psychotherapeutic conditioning of this individual for mouth intervention made it subsequently possible for invasion elsewhere.

Additional forms of conversion expression are paralysis, vague spots in the mouth, extremes of wetness or dryness in the mouth, and inability to swallow. Although there is no somatic breakdown discernible in the oral region with these symptoms, the inevitable effect of the failure to recognize the psychogenic phase is the prevention of adequate dental care for the patient.

While psychosomatic medicine is not new, it was not actually formulated until January, 1939, with the publication of a journal devoted to this phase of medicine, and following this, two books: *Psychosomatic Medicine,* by Weiss and English,* and *Psychosomatic Diagnosis* by Flanders Dunbar.[14] Published in 1946, Ryan's[4] book, *Psychobiologic Foundations in Dentistry,* is arresting. He writes: "To establish satisfactory dentist-patient relationship, the dentist needs to know what may happen to the body of man when his mind is disturbed, and what may happen to the mind and behavior of man when his body is diseased. What one experiences, the other expresses. Wounds of the spirit are expressed in malfunctioning of the body. Injury or disease of the body produces changes in feeling, tone, and emotional responses. The one word, psychosomatic, defines organismal unity and totality—no treatment can be either psychic or somatic. Every treatment is both."

PSYCHODYNAMICS OF ORAL MANIFESTATIONS

Although inadequate facts are known about the psychodynamics of oral manifestations, there are ample clinical and experimental investigations to substantiate their existence. The influence of psychic factors on salivation is well known, and pertinent observations date as far back as 1908.[5, 6] In 1938, Hinsie[7] and others made studies on human beings with various psychosomatic disorders, and found in general that parotid salivary secretion increased and reverted to the higher levels of infancy and childhood as behavior regressed to earlier levels.

The amount and pH of the saliva is influenced by emotional factors,[8] as is its composition. It is strongly possible that these factors, in turn, contribute an important part in the development of disturbances in individuals adapting to artificial teeth.

Continuing studies indicate the connections between the cortex and the autonomic nervous system, and the part emotions are contributing here. The function of the endocrine system, which is considerably influenced by emotions, contributes in an important way to the development and final structure of the teeth and periodontal tissues.[9, 10]

Dermatologists, as well as dentists, have observed that dermatologic conditions frequently manifest themselves only in the oral cavity; for instance, angioneurotic edema or lichen planus. Frequently, in these, a psychosomatic relationship can be established.

A white man, aged 47 years, married, the second of five children, was first presented in 1950 with a history of nail-biting, partial dentures not wearable at night, gastric ulcers of two years' duration, angioneurotic edema of the penis in February, 1955 (during which time he was without sexual hunger), and two weeks later of the tongue with fear of choking. He required hospitalization which was precipitated incident to his wife's failure (without his request) to demand the exit of her alcoholic brother.

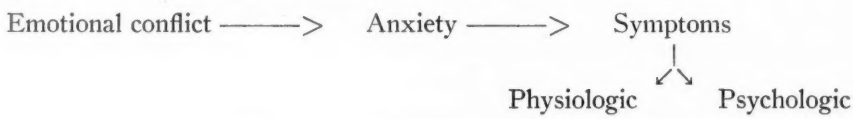
He could not assert himself emotionally, would rather give in than cause others pain, and unconsciously preferred to pay the price within himself. During this period his nail-biting was intense.

*W. B. Saunders Co., 1943.

The Rorschach test revealed a strong underlying aggressiveness, expressed only on an intellectual level as getting ahead in business. His submissiveness and control, in face of the aggressive drives, resulted in great inner tension, the masochistic element at the moment being angioneurotic edema of the tongue.

On the basis of evidence to date, we can deduce that, in the oral cavity, the psychosomatic chain of events—emotional conflict, concomitant alteration in physiology, reversible pathologic changes, irreversible pathologic changes—takes place as frequently as it does in other parts of the body. Here in the oral region, however, because of the specific anatomic structure of the tissues, pathologic changes become permanent much more readily than in other parts of the body. A tooth with attacked caries, even to a minute degree, remains carious and can only progress, never to return to its original state of health. The attempted treatment, a filling, is symptomatic, restoring the function but not eliminating the original cause of the disease. Likewise, the loss of supporting bone under artificial dentures is irreversible, necessitating alterations of the dentures.

The periodontal diseases[14] offer further proof and an example of the early irreversibility of the pathologic changes with essential loss of teeth. When the individual reaches the prosthodontist, seeking his services in terms of restoration of a disorganized occlusion, as the result of a long-standing unrecognized psychogenic syndrome, he brings with him his established personality or aging neurosis. He therefore is concerned, not only with prophylactic and therapeutic procedures, but with the holistic picture as well, for the benefit of not only immediate relief but a long-range program. Emotional conflict brings on anxiety which results in physiologic symptoms, psychologic symptoms, or both. These phenomena may be illustrated in the following schematic manner:



At the physiologic level there is dynamic activity of the mouth musculature which in turn becomes a functional disease. Distant to these two levels, psychosomatic medicine is necessary for the elucidation of the condition. The somatopsychic[11] phase of the problem may be considered valid in another way. For example, a continuous toothache, irregular position of the teeth, or unpleasant odor from the mouth may exert considerable influence on the personality of the individual. However, in such cases, a further consideration might reveal a psychosomatic relationship that caused the condition in the beginning.

PSYCHIC MECHANISMS

While there is abundant proof of the existence of psychosomatic relations in dentistry, a great deal remains to be revealed in regard to psychic mechanisms involved. Attuned to the postulate that the psychologic factors influencing physiologic processes are not unlike similar psychologic processes, the use of such general terms as tension, anxiety, and emotional disturbance in dealing with the patient can be

discarded. Instead, an actual psychologic content of an emotion should be evaluated with the latest methods of dynamic psychology, and correlated with meaningful behavior.

Another postulate to be projected into this presentation is that psychologic processes are not fundamentally different from other functions which occur in the organism.[12] They are, at the same instances, physiologic processes, and different from other bodily processes only in that they are perceived subjectively, and can be communicated to another by verbalization. Hence, they are subject to evaluation by psychologic procedures. Essentially, each bodily process is directly or indirectly influenced by psychologic stimuli, since the entire organism constitutes a unit with all of its parts interconnected. Hence, the psychosomatic approach can be readily applied to all functions occurring in the living organism. In fact, at present, without reservation, the psychosomatic point of view proffers a new and different approach to the better understanding of the organism as an integrated mechanism.

The psychosomatic aspects of the special senses[14] may emphasize that, biologically, the foremost concern of every individual is to continue to survive in his environment, or, let us say, to adapt to conditions.

Many mechanisms have developed toward accomplishing this end, but in the biologic organization of the body functions, two master, interlocked, integrated systems of tissues and organs are operative—namely, the nervous system and the circulatory system. Since the mind represents the total activity of the organism, it is generally accepted that one should expect to find emotional, and sometimes intellectual, dysfunctions associated with structural and physiologic alterations in the various organs of the body. Fortunately, modern biology has uprooted fixed lines.

Almost uniquely in the field, Mirsky[15] has formulated a design of physiologic and biochemical investigations in keeping with modern psychologic concepts. For instance: In order to delineate the contributions of the infant to the mother-child unit, he has developed procedures for the quantitative evaluation of the physiologic capacities of infants during the phase of biologic dependency. The measurement of blood pepsinogen is used as a measure of potential gastric activity. Identifying and measuring quantitatively the activity of physiologic systems from beginning of life to old age offers the possibility of identifying behavioral and psychologic concomitants, and carefully considering their interrelation. With this information, science has progressed for the first time from the observational and naturalistic, to the predictive stage. With Mirsky's technique, if one possesses the essential biologic and psychologic data, it becomes feasible not only to predict what kind of pathology will develop, but also incident to what conditions, and consequently when it will develop.

The psychic aspects of an individual are likewise functioning processes, which, under adequate conditions, are readily converted into certain physical ones.

SENSORY ZONES AND ORGANS

Sensation is the response of a special area of the organism to the first impacts of the recently stimulated "points." A prolonged permanence in the relation of

points (moments) terminates in structuralization of sensory zones and organs.

Bodily organs have many personal and social meanings for patients and so-called "normal" persons, and have resulted in a special division of our language. That is, there is an "organ language" common to all peoples:

1. Organ analogies appear often in our daily speech, e.g.: "You see, I cannot swallow such an idea"; "I cannot stomach that"; "small talk"—as if by this means one asserts his control over the line of human intercommunication; "speak up"; "keep your mouth shut"—a tendency to repress feelings of aggression and hostility.

2. Perfectly healthy organs may take on a supposed dysfunction or vague sensations that disturb the individual's equilibrium, bringing about a disproportionate relationship in the framework of health and disease.

3. Any organ, especially the mouth, may become conspicuous as a symbol of a sexual or social nature. Groddeck[18] points out that all dental operations have the peculiarity of taking place in the symbolic female organ, namely, the mouth. An analysis of fear of the dentist or a dental extraction is very instructive for the recognition of the unconscious "value" of the tooth. Likewise, the mouth and teeth play a part in "love life." The size of the teeth, prognathism and its opposite, even missing teeth, and the use of an artificial denture serve as a partial attraction up to complete fetishism. Significantly, many people like to laugh for the purpose of showing their teeth. Also, in the "ideal beauty" of other persons, the shape and color of the teeth are often of decisive importance. The teeth also fill a service in the antisexual tendencies.

In the past twenty years, psychosomatic medicine has been a subject that has provoked workers in various fields of medicine, but to a lesser extent in dentistry and gastroenterology, to obtain additional knowledge about its function under various conditions of the human organism. In the holistic picture of a human illness, there are three or more groups of factors for consideration. First is the influence of constitutional, predispositional elements, including personality type. The personality is, in a measure, the sum total of an individual's experience in life together with all of his inheritance. It is a determining factor in the patient's reaction to any situation in his life including illness and, consequently, has an important bearing on diagnosis, prognosis, and treatment. Second are the multidimensional factors that have precipitated and are chronically perpetuating the psychopathologic reaction, i.e., the phenomenology. In the third place are the mechanism and the area or system through which the principal pathology forms itself. The transition of the energy incident to the privately, consciously-felt effect takes place through the complex set of biochemical processes, which constitute the internal milieu in which a multitude of reactions take place at various "levels" of psychologic integration, as well as the functioning of various neurologic mechanisms, notably the "visceral brain" and the autonomic nervous mechanism. The real lesions represent or are the result of an energy constellation of disease that functions in the role of a maximum focus for the energy discharge, e.g., oral area or peptic ulcer. The outstanding discharge, or energy, is noticeable in the critical symptom—pain in the mouth or epigastrium. Such concept is true also for

mental symptoms. Some types of lesions, to the dentist and physician, are permanent in terms of alteration in structure: (1) cavity in a tooth or (2) peptic ulcer and consequent disturbance of function. Similarly, for example, there are some forms of anxiety that seem incapable of mobility in the structure of the patient's life and subsequently may cause therapeutic failure in psychotherapy.

The libido or basic life force (energy) is physiologic in the inclusive sense of the concept—motivations or desires are rooted in the soma and have some relationship with the brain, its extensions (the eyes), and the regulative functions of the endocrine organs. Wishes, instinctive trends, feelings of inferiority and superiority are related to the body structure; the body structure and physiology are important in libido manifestations and undoubtedly determine them. Likewise, every emotion has its effect upon the body.

ADAPTATION AND TENSIONS

In everyone there are various ways in which the person adjusts or attempts to resolve, either successfully or unsuccessfully, the primary instinctive cravings. If the adjustment of the individual to the demands of culture are "average" or "normal," it is assumed the mechanism occurred through either renunciation, "drainage" into acceptable channels, identification, or construction of an ideal. When the above goal fails, the individual becomes a misfit through maladaptations via a stronger development of the instinctive impulses, characterized by a stable, permanent "wrongdoing" life plan, displacement of cravings, becoming overcompensated, and breaking through of symptoms, or via a pathologic displacement, characterized by stronger development arrest, breaking through of symptoms, stable but active, permanent symptom-formation, and becoming overcompensated.

Certainly a person, in attempting to adapt himself, frequently appears to cling tenaciously to the symptom which he has developed, and which may be interpreted as an attempted flight from reality into illness. It therefore may be looked upon as a special way of dealing with difficulties. Psychosomatic manifestations seem to arrange themselves into a number of different dynamic clinical patterns. Some of the most commonly observed are:

1. Physiologic tensions, a normal state of nervousness which is a rather diffuse affair, a mild "readiness reaction" reminiscent of Cannon's emergency reaction, and, at times, mild organ dysfunctions with concomitant anxiety attacks. By means of self-scrutiny they may be augmented. In addition, one may speculate that self-contemplation as a theoretical exercise is strong valid evidence of a pathologic entity.

2. Conversion phenomena (hysteria) or a substitution for an emotional state which is not expressed through the usual normal channels. It is direct and symbolic, and utilizes the sense organs, or voluntary neuromuscular system, or sensory perceptive systems.

3. Symptom organization with essentially well-defined symbolic meaning. Emotional reactions often attach themselves to simple and available reflexes such as that of blushing, salivating, vomiting, urinating. The mechanism seems to be that of the conditioned reflex of Pavlov.

4. The reactions most closely connected with psychosomatic disorders are described by Wolff[16] as "protective reaction patterns." These usually select part of a system or organs, or may be local. The psychologic mechanism is dynamic and usually related to childhood patterns of behavior. Symbolization is indirect. The syndromes have little, if anything, to do with "hysteria."

5. Somatic variations, normal or abnormal, set by heredity; a precipitous physical illness upon which the neurosis centers as a scapegoat to purposely prolong convalescence and subsequent invalidism. These are common, often mild, disorders characterized by anxiety and hypochondriasis.

6. Organic disease per se frequently appears to bring about a definite neurosis. What really occurs is probably a breaking down of the individual's defense mechanism so that the predisposing factors, the basic personality structure, and the immediate problem of sufficient degree of intensity or duration allow the mental disaster to develop as another attempt at adaptation.

A white woman, 53 years of age, married, childless, was referred by a prosthodontist, with a history of having previously been to many reputable prosthodontists. During her contacts with them she had invested twenty-five thousand dollars. It is needless to state that her repetitive censorious criticism of all of them was endless. As stated before, traumatic experience within the oral cavity may be interpreted as an attack. She had refused to wear any of their appliances. The referring prosthodontist was advised that his recommendations would probably be of no avail until adequate psychotherapy was instituted. The acceptance of satisfactory appliances spelled the difference between holding on to the neurosis or giving way to psychosis.

Such widely different clinical entities are recognizable with a little scrutiny in every phase of medicine and dentistry. At this time, it is only possible to consider some of the psychosomatic disorders of the oral region and the contents of the mouth.

RELATION TO FACTORS IN PROSTHODONTICS

For the prosthodontist to pin-point or integrate the multiple factors involved in presenting prosthodontic problems in a practical dynamic way, including acceptance by the patient of the prosthodontist as a person, his analysis, the projected financial outlay, repeated chair services, and eventually any artificial denture restoration (fillings, jacket crowns, fixed bridges, inlays, partial dentures, full dentures, and obturators), it is essential for him to develop a workable concept of the longitudinal life line of the patient which emotionally begins fourteen weeks after conception or twenty-two weeks before birth. Davenport, Hooker,[19] and also Humphrey,[20] studying the behavior of human embryos, find that the first response to exteroceptive stimulation occurring at seven and a half weeks of menstrual age, is limited to the circumoral region supplied by the maxillary and mandibular divisions of the trigeminal nerve. This is the first evidence of adjustment of the embryo as a whole to its external environment.

Beader[21] and his co-workers, in studies of double simultaneous stimulation in children and adults, find the face to be dominant over all other areas.

Also, embryologically, the olfactory or snout area is connected with the mouth. Edinger, the neuroanatomist, states that the afferent fibers to the olfactory area

are probably especially concerned with feeding reflexes of the snout or nozzle, including smell, touch, taste, and muscular sensibility; a physiologic complex which can be called collectively the "oral sense." These anatomic observations point to the archaic and punitive origins of the functions invested in the perioral zone.

An essential part of the analysis conspicuously concerns our conception of dental disease, which holds that conditions which we describe as an illness always have a developmental history. The sensations, reactions, and general behavior of an afflicted person evolve over a period of time. We assume an individual to be healthy until proved to the contrary; at some point in time, however, a noxious process evolving through a series of stages comes to an ultimate termination. The disease process, with the attack and counterattack of the conflicting forces, has been going on for some time before it reaches a point where pain or insight into the subject, or the wisdom of family or friends leads to the seeking of advice and help from the prosthodontist.

The approach of the prosthodontist to the patient is actually the second step—the confirming step—in the establishment of a transactional relationship, an interpersonal contract. The first step is, after all, the patient's approach to the prosthodontist. And it is a wise and sobering experience for the prosthodontist to pause in his tightly scheduled life of active work and reflect on the question, "Why does the patient come?"

There are many accepted social phenomena of everyday life that are so common, so familiar to everyone, that we seldom give a thought to the causes back of them. Practical justification, combined with ancient tradition, makes a procedure so well accepted that to question its rationale seems somewhat captious, whereas not to question it often leads to presumptuous misunderstanding. Someone has said that understanding is the greatest boon one individual can bestow upon another. Psychologic understanding is a special kind of understanding, with technical tools of access. Some of these are characterized by the predominately psychologic nature of the patient's symptoms. But prosthodontics is not only a specialty; it is also a point of view in medicine. It is today, we believe, impossible to make the sharp distinction of mind and body which has so long prevailed—a separation that was deplored as long ago as Plato. Unfortunately, to the detriment of the patient and prosthodontist in too many instances, this separation does seem to exist. The prosthodontist with a holistic view never forgets that these eyes, and ears, and noses, and mouths, and their contents belong to persons, to personalities. The concentration upon the interaction of all parts of the body and all parts of human living constitutes what is referred to as "togetherness" of mind and body. The personality is the total individual.

In addition to being a complete personality, the individual patient is intimately connected with other individuals, with relatives, and friends, and society at large. What these others think, and believe, and threaten, and offer affects what he thinks and does. Hence the need to concentrate upon the various elements in the personality—how they function, how they vary, and how they may be modified. From this approach, we have derived some factors of human behavior in such a way that we can make predictions: we have learned about characteristics, "typical"

tendencies for inadequacy in human adaptation; likewise we have learned about effective ways to reconstruct the personality—ways usually referred to as "treatment." This point of view assumes a systematic, comprehensive survey of the suppliant patient, and an organization of the findings from such examinations so as to indicate and justify an individualistic therapeutic program.

PATIENT'S ATTITUDE TOWARD THE PROSTHODONTIST

The dental patient, especially the geriatric one with neurosis, comes to the prosthodontist with more than the desire for oral rehabilitation. Inevitably he carries with him his reaction to dental care, dental pain, and the dentist himself—his vague but powerful feelings of fear and anxiety, and his attitude toward figures in authority. One effect of this fear, perhaps the most important effect, is to increase the patient's defensiveness; at the very moment that he is approaching the dentist for help, he is withdrawing and preparing to conceal that for which he needs help. All human beings, indeed all animals, approach one another at the start with a certain tentativeness in which, as Freud has shown, there is a preliminary phase of hostility. We must establish whether the stranger comes as a friend or foe. This is much more difficult for the neurotic dental patient to do, not only because of the fears just enumerated, but because his illness has disturbed his machinery for establishing interpersonal relationships. It is like a man with a crippled hand who is introduced to the surgeon whose first impulse, before he knows the type of injury, is to shake hands—the very thing that such a patient cannot do. And just as a surgeon would have to find other means than the conventional ones for conveying his purposes, attitudes, and friendliness to this patient, so the prosthodontist must learn to depend upon many other means than the conventional ones for establishing rapport with his patients.

THE NEUROTIC DENTAL PATIENT

In addition, the neurotic dental patient differs from most dental patients in that he is likely to have dysarthrosis of the temporomandibular joints which involves not only his interpersonal relationships, and his means of communication, but his psychologic processes—intellectual, emotional, and instinctual.

A typical example of this occurred in my practice in a 56-year-old woman, wife of a successful industrial executive, under observation for over ten years for various conditions, including migraine[15] (such individuals show certain typical personality features and reactions), grinding of teeth, nail-biting, cracking of the left jaw on mastication, and severe recurrent attacks of dizziness and vertigo. Recently the vertigo was so severe that, while sitting on the side of the bed adjusting her shoe, she was thrown forward onto the floor, with accompanying nausea and vomiting, where she remained for two hours in a state of shock before discovery. This patient, of Irish-Swiss extraction, was the fifteenth child, born and reared on a ranch in Wyoming. Her early life had been unhappy because her mother was domineering and inconsiderate. She had been subject to attacks of syncope. To this day, an attack of migraine may be precipitated by a verbal attack by the sister. The patient's father was rather shiftless, and, in the sexual area of training, was austere. At 17 years of age she was married happily,

and two years later an only son was born. To the present, she has devoted herself to the welfare of her family. This patient was exaggeratedly dependent on her mother, serious, conscientious, meticulous, of superior intelligence, overly ambitious, reserved, relaxed, dignified, sensitive, domineering, perfectionistic, incapable of satisfactory sexual adjustment, highly sensitive to dirt, and unable to delegate responsibility. Her chief recreations were reading and golfing; and she took a very active part in church work, being from time to time chairman of various committees. She had a need to gain favor by serving others, but frequently became involved in situations of conflict.

When first seen, she complained of periodic, unilateral headaches since the age of 5, with disturbance of vision, nausea and vomiting, always preceded by spurts of energy. About the age of 10 she suffered from conjunctivitis, allegedly due to exposure to snow, at which time she was hospitalized ten months. Many times repeated ophthalmologic examinations were sought with refitting of glasses. At 35 years of age, her weight had increased to 235 pounds, and she had a basal metabolic rate sufficiently low to require 4 to 6 grains of thyroid extract daily. Also, for the past twenty years, she has experienced recurrent acute attacks of duodenal ulcers with three episodes of hemorrhages. During the past thirty years she was periodically annoyed with recurrent attacks of frequency and urgency of urination, and at times with acute symptoms of cystitis. On several occasions she submitted to exploratory genitourinary examinations, all of which were found to be negative. At 39 years of age, she was exposed to radium for metrorrhagia which ended in permanent cessation of menstruation. For the past nine years she has experienced recurrent attacks of angina pectoris and fluctuating hypertension between intervals of migrane, each following a burst of excess energy. The Rorschach test revealed superior intelligence with decreased performance due to conflict in actual use of her good mind. Compensatory drives were especially great on the intellectual level. However, when pushed to the ultimate she was capable of practical and concrete performance. She was emotionally overresponsive without adequate control, along with swings of mood and strong elements of depression. She was unable to accept her sexual drives, equating them with the idea of dirt and something ignoble. In dealings with others, the Rorschach showed evidence of hostility, fault-finding, irritability, oversensitivity, and inability to take suggestions. One would expect hysterical and conversion symptoms and compulsiveness. Psychotherapy directed toward developing an insight into the basic mechanism and relief from intra- and extramural responsibilities resulted in a definite improvement.

In this case, the migraine and the dental problems were only two manifestations of this patient's internal conflict (foci of conflict). Psychotherapy progressed much more rapidly, with the aid of the prosthodontist, after correction of the disorganized occlusion by removal of the ever-recurring trigger mechanism.

NEUROTIC CHARACTERISTICS IN THE PROSTHODONTIST

Similar characteristics may also exist in the prosthodontist, in which case, indeed, they may be the very same ones which the prosthodontist is using in his efforts to observe and understand the patient. Hence, the patient's behavior and symptoms often awaken impulses, associations, and reactions within us which we are having difficulty enough of our own to manage.

A young, married, ambitious dentist, with an announced goal directed toward prosthodontics, in his early thirties (and this may apply to many prosthodontists since aging increases neurosis), became aware of his resistance toward obvious neurotic dental patients. He wisely sought an evaluation of his personality. The Rorschach study revealed the following details: He was courteous and cooperative, but his attitude was one of wariness. He was noncommittal as to the reason for the test. Answers to personal history such as age, formal training, marital status were curtly discussed. His productivity was moderately below the average number of responses, with his associations quite banal and commonplace. He became not only evasive but defensive when pressed for more precise description as to what was his impression of the card game. His approach was superficial with impressions given impulsively, without careful discrimination and discernment. A definite tendency to deny a percept suggested a blurred perception of situations even though he was fully aware of, and endorses, the conventional thinking of his milieu. An undercurrent of negativistic, obliquely hypercritical (this was especially true in the relationship with his wife and dental associate in his office) maneuvering was felt throughout the test with a placing of the blame on the tester for requiring him to overproduce. A great reliance upon conscious repression, as well as an established mechanism he utilizes to control his hostility, was evidenced by such remarks as, "Other than that, no impression whatsoever."

He appears to be self-centered and does not question his own motives or behavior; he acts with assertion and certitude. Although capable of constructive and efficient work, creativity and originality are curbed. He functions by internal impulse without adequate resources to mull over a situation before acting. He appears to act, and then think afterwards, which would raise the question of how well he could handle stress situations (and how frequently stressful situations arise in prosthodontics!). A surface gaiety covers a more depressed attitude. Not only is he ineffective in dealing with perceptual tasks or situations, but with interpersonal relationships as well. His attitude toward others is belittling (for example, toward his wife, dental associate, and neurotic dental patients) in order to make others more submissive and easily manipulated, and less of a competitive threat. He undoubtedly is afraid of his hostile and destructive impulses which have not been integrated in his work.

He is sensitive and has a need for belongingness; however, this sensitivity appears directed toward himself more than toward others in understanding and reciprocating. He is so strongly moved by an emotional impact that control is difficult. He is successful, for the most part, in controlling overt expressions even to the point of seeming reserved and inhibited. Yet, he controls by not showing his feelings.

There is evidence that true cathexis is with his own sex, but he acts out a heterosexual role as a denial of his own sex confusion. And, as a further denial, it would seem he regards women as exploitable, even though he treats them with respect which covers an airy contempt and refusal to accept them as equals. His attitudes appear to be derived from an unresolved relationship with a strong and patriarchal father-figure, and a punitive and rejecting mother-figure. He is unable to tolerate his deep-seated needs for nurture and dependency which lead to a sense of inferiority in social contacts; consequently he derives little satisfaction in normal life situations.

CORRELATION BY THE PROSTHODONTIST

Accordingly, such reactions tend to upset the prosthodontist and disturb his objectivity. They may arouse pity rather than sympathy; anger rather than regret;

contempt rather than curiosity; erotic feelings rather than friendliness; anxiety about oneself instead of concern about the patient. Primitive vigilance, minus social communication, equals anxiety.[16] The patient's problems force him, or perhaps let us say permit him, to do things which we do not permit ourselves to do, and sometimes this has the tendency to create envy and resentment. The patient may be provocative; he may be seductive. These are some of the ways in which the neurotic differs from the nonneurotic dental patient, dictating a different approach from both sides. It probably sounds appallingly difficult to the novice, but the task must be done; for only the prosthodontist is qualified by training and experience. The task can be done, is being done, and has been done very skillfully by many. At times, it may be necessary to share the responsibility with the referring physician oriented in the subject. For various reasons, such a physician, when referring a problem dental patient, can be of great help in preparing the patient for prosthodontics, and further effectively assist, when needed, to overcome temporary impasses to the advantage of all concerned. This approach can be learned, but it must be learned with much trial-and-error experience. As in any other kind of therapeutic endeavor, the prosthodontist is of particular importance. The degree of his success will be determined by his solidity, as well as the flexibility of his own personality integration, suitability of temperament, empathic entities, knowledge of complexities of behavior, and his training and experience in this specialty. Progress made during the last decade and a half has rendered the prosthodontist considerably more aware of his role. He is becoming increasingly precise in the application of old ideas which he formerly criticized as "too new." Gradually, a certain attitude will develop which will enable him to do this with an almost automatic correctness.

SUMMARY AND CONCLUSIONS

1. The principles of psychosomatic medicine in dentistry have been presented in order that the influence of psychic factors in prosthodontics can be better understood and managed.

2. As in other body systems, the mouth, when subjected to prolonged but reversible physiologic disturbance incident to psychosomatic conflict, can eventually give rise to irreversible organic disease.

3. Some common oral manifestations of disturbed psychosomatic interrelationships were discussed.

4. No longer can the prosthodontist, with better understanding of both the patient and himself, remain content to treat a psychosomatic disturbance by merely asking the patient to answer a few terse questions, to submit to roentgenography, etc. In cases of the oral disturbances described, patients should be given the opportunity for preventive psychotherapy in which defects of personality or neurotic conflicts are dealt with, even though these psychic disturbances may not, from a dental point of view, seem directly related to the existing dental disturbances.

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VALUE OF THE HINGE AXIS RECORD

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THE BASIC COMPONENTS of condylar movement are rotation and translation. Varying degrees of correlation between these components will affect the pattern of mandibular movement. If both condyles describe similar paths of movement, the mandible will then undergo either a protrusive or a hingelike movement, depending upon the ratio of the components. Lateral mandibular deviations occur when the ratio of the components making up condylar movement differs in each condyle. Stated briefly, mandibular path and position are determined by four variables:

Rotation condyle L
Translation condyle L
Rotation condyle R
Translation condyle R
= Mandibular path and position

The use of a hinge axis record is predicated upon the supposition that the rotational component of each condyle can be isolated and recorded. Early experimentation along these lines was performed on a cadaver.[1] It was demonstrated that by depressing the mandible, one point on the condyle remained stationary. Attachment of a hinge axis recorder on a live individual apparently further demonstrated the presence of a hinge axis clinically.

In the experiment performed upon the cadaver, the mandible was opened by the application of a force in the incisal region. Anatomic visualization of the method employed would denote solely that the mandible was depressed by stretching the fibers of the elevator muscles of the mandible. This does not necessarily demonstrate the normal method nor the path of the mandible in opening. It is understood that opening is accomplished by the inframandibular musculature, plus the action of the external pterygoids which are of prime importance in translatory movement. Since none of these muscles could possibly function during the experiment conducted upon the cadaver, it cannot be stated with accuracy that the true condylar movement was visualized. The method of opening was not a true one.

It can be readily demonstrated that a hinge axis recorder will show one spot in the preauricular region wherein no movement of the stylus occurs when the mandible is voluntarily depressed and elevated. This location is taken to be the hinge axis traversing the condyles. There is a possibility that the hinge axis does exist, but it may not be necessarily located within the condyles. Depression of the mandible in a hingelike opening may cause the condyle to traverse a radial arc of its own, due to the influence of the external pterygoid musculature. The area demonstrated by the stylus may denote the radius of the arc described by the condyle, and may not necessarily exist within the condyle. Hence, we might be dealing with an imaginary axis rather than a true condylar axis of rotation.

Received for publication March 15, 1955.

PROBLEMS OF TRANSFER

The inferences drawn appear to negate the value of hinge axis recordings, but notwithstanding the possible fallacies in the principle, it is assumed that the possibility definitely exists for a demonstration of a valid hinge axis passing through or near both condyles. The problem of transfer and utilization of the axis record remains. The modern hinge axis recorder, as commonly used, is extremely precise and possesses the ability to indicate a very small area in the preauricular region, at which point the stylus does not translate in mandibular opening and closure. One millimeter of deviation from the axis point introduces translatory movement by the stylus.

The transfer to an articulator is done by means of an upper jaw clutch orientation to the axis, and thence to the articulator. The maxillary clutch must fit the maxillary cast so accurately that the stylus does not deviate 1 mm. from the articulator axis, even though the anterior teeth in the cast may be as much as 5 inches away from the articulator axis. For comparison, consider the large opening created between incisors when the molar occlusal level acts as a fulcrum and is raised 0.5 mm. Remember that less than 2 inches separate the molar region from the incisors. It is extremely difficult to visualize a plaster cast so perfectly identical to the mouth that the clutch fits it exactly as it does the mouth. If the tip of any tooth fails to seat exactly into the clutch, the error in positional relationship, 3 to 5 inches away in the articulator axis region, could be considerable. If the articulator is to function with the same axis of rotation as the mouth, the casts must be related to the articulator axis exactly as the jaws are related to the condylar axis (if such an axis exists). The concept of hinge axis recording maintains that the translatory and rotational components can be separated and recorded individually.

ECCENTRIC MANDIBULAR POSITION

The eccentric mandibular position is a translatory movement upon which a rotational component is superimposed, so that the required vertical dimension can be assumed in order that cusps may pass over cusp inclines. The distance from the condyle to lower incisors is constant in a given patient because both elements are a part of or firmly attached in the same bone, namely, the mandible. In any and all movements of the mandible the condylo-incisal distance is always constant, and the hinge axis travels with the condyle (according to hinge axis concepts).

ARTICULATOR ERRORS

In most modern articulators, however, the elements of the mechanical joint are reversed.[2] The condylar guidance on the machine is attached to the lower member, and the ball or articulator axis is attached to the upper member of the articulator. Thus, in eccentric movements of the articulator, the condylar axis moves backward, increasing the condylo-incisal distance, with a resultant change in the radius for the arc of closure. The machine will not duplicate the path of movement of the mandible, and true duplication of anatomic mandibular movement is unattainable.

This basic flaw in articulator design has been recognized and corrected by attaching the axis elements of the articulator to its lower member. This has been

done in order to represent better the actual anatomic situation.[1, 3] Except for instruments with this modification, the present-day articulators, such as the House and Hanau, etc., are totally useless for reproducing *eccentric pathways* when their use is predicated upon the use of a hinge axis transfer.

THE HINGE AXIS RECORD

The exponents of the hinge axis school assume that the patient can open and close with a hinge movement which is devoid of condylar translation. The proof of pure rotary movement is the fixation of the stylus in the preauricular region. This fixation may be an indication of an imaginary axis outside the condyle. However, granting a true condylar axis, the presence of the clutch attachment on the mandible prevents its closure to a contact relationship. The contact relationship must be made by means of an interposed substance, such as wax, compound, plaster, or alginate. The inherent errors in the setting of these materials, compounded by the errors in the casts, frequently preclude the setting of the casts in relation to each other with absolute accuracy. The use of other methods of making centric and eccentric registrations may also lead to error. The use of the maxillomandibular face-bows with the six-stylus technique presupposes the accuracy of two clutch mounts on two casts. The possibility of inaccuracy of mounting clutches to casts has been discussed. Moreover, the use of the six-stylus technique merely indicates the relationship of the mandible to the maxillae as influenced by a guide plate and pin interposed between the jaws. The insertion of the guide plate is arbitrary, and alteration of its placement and angulation will affect the rotational component of condylar movement. The information provided by this technique merely registers one possible path of condylar movement, and does not prove that it is the correct path, or that the cuspal inclines of teeth must balance with it.

CONCLUSION

The analysis of condylar movement reveals that translatory and rotational components in varying proportions affect the path and location of the condyle in movement. It has not been ascertained conclusively that any condylar movement occurs normally as the result of the activity of one component solely. The demonstration of a possible hinge axis is an interesting phenomenon, but its application to restorative procedures is open to question, and its value may prove to be only theoretical.

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APPLICATION OF THE HANAU MODEL "C" FACE-BOW

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A TECHNIQUE FOR THE application of the Hanau Model "C" face-bow in full denture construction is to be discussed. The advantages of this type of face-bow, its limitations, and the reasons for its use as an essential phase of any procedure in complete denture construction will be considered.

The face-bow is an auxiliary device for use in complete denture construction. The function of the face-bow transfer is to reproduce on the articulator the positional relationship of the maxillary ridge to the temporomandibular joints. Some articulators, such as the Stansbery tripod, do not require registration of this positional relationship. The model "C" face-bow, and many others are predicated upon an arbitrary location of the opening axis of the mandible. This approximation works well in regular denture construction, and it is better to use this method than not use a face-bow at all.

The advantages of a face-bow mounting are as follows:

1. It permits a more accurate use of lateral rotation points for the arrangement of teeth.

2. It aids in securing the anteroposterior cast position with relation to the condyles of the mandible.

3. It registers the horizontal relationship of the casts quite accurately, and thus assists in correctly locating the incisal plane.

4. It is an aid in the vertical positioning of the casts on the articulator.

THE FACE-BOW TRANSFER TECHNIQUE

1. Attach the bite fork to the maxillary occlusion rim. The maxillary occlusion rim is used because it exhibits greater stability than the mandibular one.

2. Draw an indelible pencil line from the upper border of the tragus of the ear to the lateral corner of the eye. Bisect this line with another line drawn approximately 11 mm. anterior to the tragus. The condyle is located approximately at the position where these lines cross (Fig. 1). Repeat this procedure on the opposite side of the face.

3. Adjust the face-bow. Select any reading on one calibrated scale, such as 7, and lock the condyle rod in this position. Place the face-bow in position with the locked side making a light contact on the skin at marked point. Touch

Presented as a clinic before the American Denture Society at Miami, Fla., Nov. 6, 1954.
Received for publication March 7, 1955.
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the skin lightly with the condyle rod on the opposite side, and note reading on the calibrated scale. Add the two readings together and divide by two. This figure will represent the calibration at which the condyle rods should be set on both sides. The objective is to center the readings on the face, and later to center the readings on the articulator. Since the intercondylar distance on the face is variable, but fixed on the articulator, the centering figures obtained on the face need not coincide with those on the articulator.

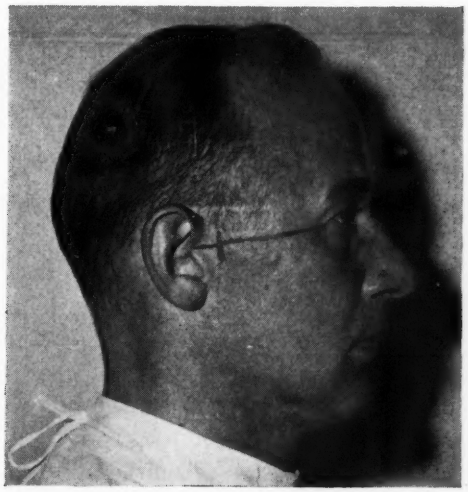

Fig. 1.—Bisected line showing the location of the condyle.

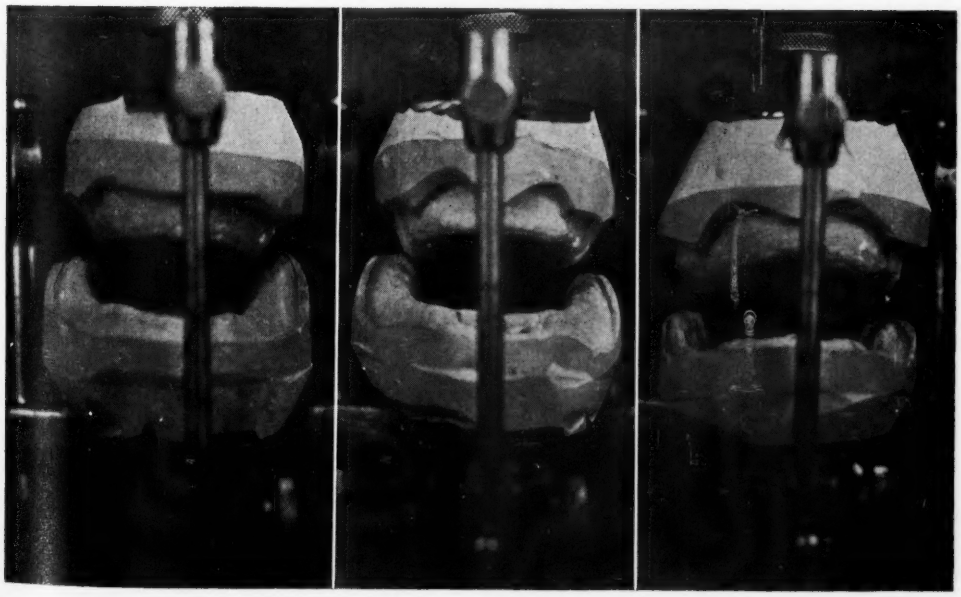

Fig. 2.—Mountings for three patients made with Hanau Model "C" Face-bow. Note the variations and asymmetry. This could not be duplicated without the face-bow.

4. Place the maxillary occlusion rim with the bite fork attached in the patient's mouth. Place the mandibular occlusion rim in position, and have the patient close the mouth.

5. Attach the face-bow to the bite fork. Be sure the calibrations on the condyle rods are equal on both sides. Lock the face-bow to the bite fork and remove the entire assemblage.

6. Transfer the assemblage to the articulator, and center the face-bow by readjusting the condyle rods to equal readings on each side. Complete the mounting.

An average level for the occlusal plane has been indicated in many articulators. In the Hanau Model "H" articulator, this is marked by a groove in the incisal pin. An alternate method is to place the bite fork in the upper occlusion rim so that the handle is parallel with a line drawn from the upper part of the tragus of the ear to the lower edge of the nostril when the occlusion rim and fork are placed in the patient's mouth. It is located on the Camper Plane. The upper occlusion rim is mounted after the face-bow is attached so the handle of the bite fork is parallel with the lower member of the articulator.

A frequent comment in reference to the use of the face-bow is that the mounting "does not look right" when the casts are mounted on the articulator. This arises from a well-established habit of mounting the occlusion rims empirically in the center of the articulator, in such manner that they will present an esthetic and symmetrical appearance. This is in direct contradiction to the actual or true position of the occlusion rims as established in the mouth. The very asymmetry of face-bow mountings is an indication of their value. The true positional relation can quickly and accurately be transferred from the mouth to the articulator by the application of the face-bow (Fig. 2).

SUMMARY

1. The advantages to be gained by using the Hanau Model "C" face-bow have been enumerated.

2. A simplified method for the application of this type of face-bow has been presented.

3. The use of this auxiliary device is neither time-consuming nor complicated. It requires approximately five minutes.

4. Diligent application of this face-bow will result in further study and experimentation, with a realization of its true value as an auxiliary device in complete denture construction.

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AN ANALYSIS OF THE TONGUE FACTOR AND ITS FUNCTIONING AREAS IN DENTAL PROSTHESIS

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THE TONGUE HAS been a very disturbing factor in every phase of dental prosthesis. Since this tongue factor cannot be eliminated, it must be accommodated. It is my purpose to analyze this problem, and to present a functional classification as an aid in individualizing the approach to the prosthetic problem, thereby increasing the ability to effect a solution. The need and method of affording adequate tongue space will be fully discussed.

The production of maximum functional rehabilitation with respect to the tongue has been recognized by many. Evaluation of this frequently disturbing factor is my purpose. The degree of change of the range and power thrusts of the active tongue is a variable that warrants consideration in any planned endeavor for the solution of individual prosthetic problems.

The tongue may be briefly described as follows:

> "It is a muscular organ intimately associated with the function of taste, speech and deglutition. It is situated partly in the mouth and partly in the pharynx. Through the medium of its constituent muscles, it is attached to the hyoid bone, the mandible, the styloid processes, the soft wall of the palate and the pharynx. It possesses a root, a tip, a curved dorsum and an inferior surface."[1]

What part does the tongue play in affecting the result of a prosthetic restoration? The establishment of the plane of occlusion and tooth positioning in complete dentures has been reduced to what is designated as an established relationship, yet Fish,[2] supported by the dissections of Garmony[3] and the findings of Burkitt and Lightoller,[4] emphasizes the importance of accommodating the functional area of the tongue, muscles, and ligaments to insure stability of lower dentures. This theory, as applied to their concepts, demands inquiry by all interested in complete denture prosthesis.

It is an obvious conclusion that comprehension of the tongue function and its operating area in both the buccal cavity and the vestibular space is a prerequisite in achieving or approaching the ideal dental prosthesis.

The many papers discussing oral physiology, involving occlusion (in active mastication) without incorporating the tongue factor in the masticatory physiology,

Received for publication Feb. 16, 1955.

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present an incomplete picture of functional physiology in mastication. The part played by the lips, modioli, and cheeks with the entire mechanism of the floor of the mouth, salivary and mucous glands, muscles, and ligaments of mastication, plus the innervation of the motor and sensory nerves must also be considered.

While there is a bilateral action in the physiology of mastication, the efficiency varies agreeably to function; just as a person has two legs in function, but may be more efficient with one or the other (depending on greater use of one over the other) when all other factors are equal.

THE FUNCTIONS OF THE TONGUE

The functions of the tongue are as follows:

1. It is a necessary part of the instrument of articulate speech.
2. It acts like a reed in a wood-wind instrument to effect variations of sound qualities.
3. It moistens lips to facilitate speech. This is an important, yet frequently overlook observation.
4. It acts as an improved conveyor belt to help complete the process of mastication by gathering, holding, and assisting food to the food table for complete mastication before deglutition.
5. It also aids as a vehicle to direct the masticated bolus to the oropharynx.
6. It helps control and guide the fluid intake to the pharynx.
7. It contains the greatest number of the taste organs and mucin-secreting glands.
8. It acts as an additional thermal guide to determine acceptable temperatures for solid or fluid intake in the buccal cavity.
9. It has the transient and permanent power to change form in order to effect better speech patterns or in the general function of mastication. Permanent changes are due to alterations in the functioning area as is illustrated in the wear of natural teeth, loss of one or more natural teeth, resorption of alveolar ridges, thumb-sucking, or habits that alter the form of the jaws or tooth positions, in malocclusion, tooth drifting, in paradontosis and traumatic occlusion.
10. It serves as an eliminating instrument with the lips and breath to expectorate foreign, undesirable, or irritating substances.
11. It is a contributing factor in aiding normal positioning of erupting teeth in the dental arches as a counterpressure to the facial muscles on the labial and buccal side of teeth.
12. It aids in depressing the soft palate to eliminate mucous, sinus, and lacrymal secretions.
13. It aids in the retention of ill-fitting dentures.
14. It aids in forming negative pressure to force tenacious secretions in the buccal cavity.
15. It helps block the trachea in deglutition to keep food out of the bronchial tract.
16. It effects displacement and compression of air, thereby helping create suction in swallowing.

THE FUNCTIONING SPACE OF THE TONGUE

The functioning space of the tongue is generally called the buccal cavity. The mandible, which contains the tongue, may be graphically labeled "the tongue receptacle," with the lingual surfaces of the maxillary teeth, when present, the hard and soft palate, and the oropharynx, combined, forming the lid or cover. Obviously, when no teeth are present, the barrier between the oral space and the vestibule of the mouth is greatly lessened. The largest active functioning area is achieved when the jaws are widest apart by addition of the interdental or maxillomandibular space. At this time, the vestibule of the buccal cavity must be noted as a vital part of the functioning space. The vestibule, which contains the buccal pouches, is described as follows: It is the space labial and buccal to the maxillary and mandibular dentition and jaws. Above and below, it is limited by the reflection of the mucous membrane from the lips and cheeks to the mucosa covering the upper and lower alveolar arch. It receives the secretion from the parotid, buccal, molar, and labial glands, and communicates, when the jaws are closed, with the cavum oris by an aperture on each side behind the third molars, and by narrow clefts between opposing teeth (interdental spaces).

It is common knowledge that loss of one or more teeth, especially the posterior members, unless promptly replaced, results in a sequence of changes in the functioning space. This also is effected in a less abrupt and more gradual degree with normal occlusal wear. The characteristic marginal scalloped tongue indentations (lingua dentoformata) result.

THE VESTIBULAR SPACE

With the loss of posterior teeth, there is an interesting redistribution of the vestibular and tongue spaces. In most cases, the vestibular space is increased in the mandibular region, and decreased in the maxillary area. The reason for this is that the mandibular molars usually tilt forward and lingually, thereby reducing the mandibular tongue space, which results in a corresponding increase in the vestibular space; and the maxillary molars tilt buccally and effect an increase in the intramaxillary tongue space at the expense of the vestibular space. A study of these space changes may be an additional key to improved esthetics.

The buccal pouch is confined by the modiolus which is the focal point of eight facial muscles. This hub prevents the loss of food through the lips during mastication. The absence of the modiolus may be observed in some animals, such as dogs, which are compelled to tilt the head upward, and thereby depend on gravity to avoid the loss of particles of food. In this respect, the failure in human beings to function adequately is evidenced by the dribbling or loss of food, as observed in Bell's palsy. The muscles forming the modiolus are:

Orbicularis oris	Triangularis
Zygomaticus major	Risorius
Zygomaticus minor	Levator Labii Sup.
Buccinator	Levator Anguli Oris

The distal border of the sublingual space is the dam over which the fluid level must rise to cause deglutition. The dam is formed by the palatoglossus muscle crossing from the posterior undersurface of the tongue up to the soft palate, thereby forming the anterior pillar of the fauces. Overextension of a partial or complete denture flange here would restrict normal function, and tend to lift the denture forward when the tongue is raised in action. Encroachment at this location in debilitated types of patients may not result in lesions, for the functional force is insufficient to cause lacerations. Nevertheless discomfort results. Such patients are dismissed as hopeless hypochondriacs, as they seemingly complain for no apparent reason. More happiness may be anticipated for both the patient and prosthodontist if discomforting encroachments are recognized and eliminated or accommodated. Mechanical locking of dentures at the expense of function and potential trauma is contraindicated. Increased mandibular denture coverage should not be attained at the expense of necessary tongue space, if well-functioning and comfortably stable dentures are the objective.

THE DORSUM OF THE TONGUE IN ITS REFERENCE POSITION TO THE TOOTH PLANE

The dorsum of the tongue in its reference position to the tooth plane of occlusion is influenced by three factors: (1) the height of the body of the mandible (receptacle), (a) shallow, (b) medium, (c) deep; (2) excessive wear or loss of occlusal and incisal surfaces of natural dentitions, or resorption of ridges under complete dentures; (3) premature loss of one or more teeth, especially the bicuspids and molars. There may be a combination of these factors.

Obviously, a thin shallow mandible (receptacle) will present a high-set dorsum, and this demands a tooth plane alignment that is level with the tongue dorsum; while a stout or deep-set mandible permits the selection of a plane below the dorsum level. These levels are determined with the jaw open and the tongue at rest in the mandible.

The tongue position in relation to the floor level of the tongue space may be classified as follows: (a) highest level when the tongue is protruded as far forward as possible, (b) medium level when the tip of the tongue is in contact with the incisal edge of the mandibular incisors, and (c) lowest level when the tongue is at rest.

FUNCTIONAL TONGUE CLASSIFICATION

The working range of the mobile tongue varies with the individual. Therefore, classification and knowledge of the conditions that cause variations are indicated.

Few organs in the body are prone to change and return to form as frequently as the tongue. The degree of activity and the variation in functional type suggest the following classification:

1. The occupational tongue.
2. The still tongue.
3. The normal tongue.
4. The habitual tongue.

The term *"occupational tongue"* was selected to apply to those people whose activities require increased tongue action. This includes jurists, teachers, lecturers, and preachers. Musicians employing brass or wood-wind instruments are also in this category. The developed increased muscular positioning force will hereinafter be designated "tongue power movements." In other words, the "occupational tongue" implies that the organ has developed a greater range of power movements, which may result in trauma where flexibility in range is interfered with or restricted by prosthetic appliances.

The *"still tongue"* is at the opposite end of the classification. In these patients, as a result of limited activity, due to injury, deformity, or undue timidity, a passive tongue exists. An example is ankyloglossia (tongue-tie) which is due to faulty development. According to Thoma,[5] "The tongue is limited in its movements and cannot be projected forward. This may be due to a short frenum, or one attached far forward on the tongue." In the case of the mute, as a result of early loss of speech, a more passive tongue is evident. In this group, the range of tongue freedom is not nearly as essential a consideration as in the occupational group. Those individuals may be included in the passive group where the quality of muscular tone indicates complete or partial disfunction atrophy.

The *"normal tongue"* exists between these two extreme ranges and refers to the type of tongue function in people exhibiting a normal or average development. These cases are welcomed by the prosthodontist, as they give a range within limits in effecting desirable rehabilitation. Functional freedom may be increased or restricted for the benefit of the case at hand. This may be illustrated by closing the vertical dimension from the ideal to attain greater complete denture stability in patients disclosing extreme maxillo-mandibular ridge resorption. The opposite condition is evident where it is preferable to effect an increased occlusal vertical dimension in favorable cases in order to improve esthetics. The patients with normal tongues permit this range of choice. The phase of the problem, however, that demands particular consideration is obviously where extreme power movements are developed. The "occupational tongue," which possesses a degree of tone that exceeds the average grouping, compels activity without irritating interference.

Tooth alignment should be effected without encroachment upon the tongue functioning space. The base of the tongue is frequently "hooked" by the lower second molars. This factor is a cause of unstable lower dentures which warrants recognition. Positioning lower second molars in complete dentures should be arranged without tongue impingement. In some cases, the insertion of a fixed appliance or removable partial denture will cause immediate tongue laceration of varying degrees. The traumatic problem in occupational tongues has a favorable prognosis with early recognition and adequate adjustment to the problem. Observation confirms the fact that tongue laceration rarely results from functional tongue interference in complete dentures, for the power movement of the tongue is capable of dislodging the interfering dentures, and thereby escaping injury. The value in straddling interference of flange margins upon the tongue is in

effecting better denture stability in function. The reaction of the tongue to interference with power thrusts by removable partial dentures or fixed bridges presents a different picture. The inability of the tongue to escape or dislodge the appliances results in repeated irritation or trauma. The degree of injury is commensurate with the duration of time and the intensity of the interference.

The *"habitual tongue"* is the final group. The term is chosen to describe those disturbing power movements developed by habit, exclusive of the arching of the tongue to help retain dentures as described by Rowe.[6] The base of the tongue is thick and powerful, and the dislodging force is most offending to prosthetic dentures. It is suggested that the lower second molars in prosthesis may be reduced buccolingually, and may be set buccal to the ridge crest to negate the objectionable effects of classic accepted tooth position that frequently tend to defeat lower denture stability. When narrowing of the last lower molars in complete dentures fails to give sufficient functional tongue space, it is advisable to set the combined opposing last molars in buccal version, reducing the lingual surface linguobuccally, in distal progression. It is also possible to increase tongue space for better function by placing the last molars in a cross-bite relation. The employment of a cross-bite to effect greater tongue space is a new use for this method. In extreme cases, the second molars can be eliminated completely.

TONGUE ENLARGEMENT

This subject could hardly be considered complete without mentioning some of the tongue conditions that cause permanent enlargement of the organ. The role of the tongue in phonetics should also be indicated. In the first instance, there is macroglossia, sometimes referred to as lingua plicata (furrowed tongue, scrotal tongue). In acromegaly, cretinism, and mongolian idiocy, the tongue is larger than usual. This often happens in partial lingual paralysis, causing atrophy on one side and hypertrophy on the other. It is a preventive plan to lessen the mechanical irritation factor as one of the causative agents of epithelioma.

THE TONGUE FACTOR IN SPEECH

It is an exceedingly rare case where a spoken word does not, at some syllable, strike or slide over part of the lingual surfaces of teeth, as the tongue performs the actual mechanics of forming the correct articulation of words within the oral cavity. The tongue uses the upper and lower teeth as a springboard in catapulting words such as "tremble," etc. As the last syllable is pronounced, the tongue contacts the front teeth. Without a balanced smoothness, irritation results. The professional speaker misses, seriously, a single tooth which is absent, with the exception of the third molars. The tongue is lacking a necessary instrument, and this makes articulation more difficult. To a trained ear, the deficiency in the mechanism of speech quickly becomes apparent.

The absence of any tooth, especially a molar, may cause a hissing sound, for very often the tongue acts as a brake on surplus air in the oral cavity, pressing against upper or lower tooth structures. Consequently, with a tooth

missing, it is more than the tongue can manage. The prime factor, of course, is the importance of a related smoothness in the oral cavity without intermittent gaps, so that no obstruction is felt by the tongue. This smoothness factor may be unduly magnified by very sensitive persons, but it necessitates due consideration. The tip of the tongue possesses an extremely noticeable tactile sense. The annoyance resulting from replacement of a prosthetic part, whether an inlay, filling, or bridge, is capable of causing considerable discomfort. Pontics that are too thick and encroach upon the tongue range must frequently be reduced to re-establish tolerance. This is especially true for the group in the "occupational" classification.

SUMMARY

1. An analysis of the tongue function and its working spaces is submitted.

2. The dorsum of the tongue in its reference position to the tooth plane is discussed.

3. A more detailed study of the alteration and redistribution of the tongue and vestibular space is suggested.

4. A functional classification of tongues affords information necessary for adequate prognosis in dental prosthesis.

5. Methods of increasing tongue space are suggested.

6. The tongue factor in speech is outlined.

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THE PARTIAL DENTURE BASE

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THE BASE IS A MOST important unit in the successful functioning of the partial denture. This study will be directed particularly toward a consideration of that type of base having at least one free end, since it presents so many problems in the achievement and maintenance of appliance support. Unless a free-end base continues to receive stable support from the ridge tissues during its life of service, the appliance may become a destructive lever due to its lateral and vertical movement.

This type of prosthesis (Fig. 1) is quite properly termed a "partial denture" having as it does a composite support, the major portion of which comes from the tissues underlying the free-end base but with minor support coming from selected abutment teeth. For this type of restoration, the impression problems are quite unlike those encountered in the case of the completely tooth-borne bridge (Fig. 2), or the entirely tissue-supported complete denture. Support for the partial denture comes from two entirely dissimilar oral structures: the teeth and residual ridge tissues. In both the removable bridge and the complete denture all support comes from a single source, certain selected abutment teeth for the bridge (Fig. 2) and ridge tissues for the complete denture. While this may allow a simplification of the impression procedure, it is not intimated that either the tooth-borne appliance or the tissue-supported denture needs a less meticulous impression method. The point which should be clearly emphasized, however, is that the approach to the partial denture impression must of necessity be modified from that used for either of the other two types of removable dental appliances, since the source of support is so completely different.

FACTORS AFFECTING STABILITY

The factors which are most likely to affect the stability of the free-end partial denture base should first be noted. Its tendency to move laterally or vertically will result in the tilting or twisting of abutment teeth. When applied forces are transmitted through the partial denture acting as a lever, they are magnified in direct proportion to the lever length, the amount of occlusal force applied, and the degree of base movement which occurs. Conditions which would

Read before the American Denture Society at Miami Beach, Fla., Nov. 5, 1954.

Received for publication Jan. 22, 1955.

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aggravate movement of the base during functional or other activities (as in bruxism) must be noted and their control accomplished, if the partial denture is to be used without damage to the abutment teeth and the remaining oral tissues. Among such contributing factors is a hyperplastic tissue covering of the residual ridge;

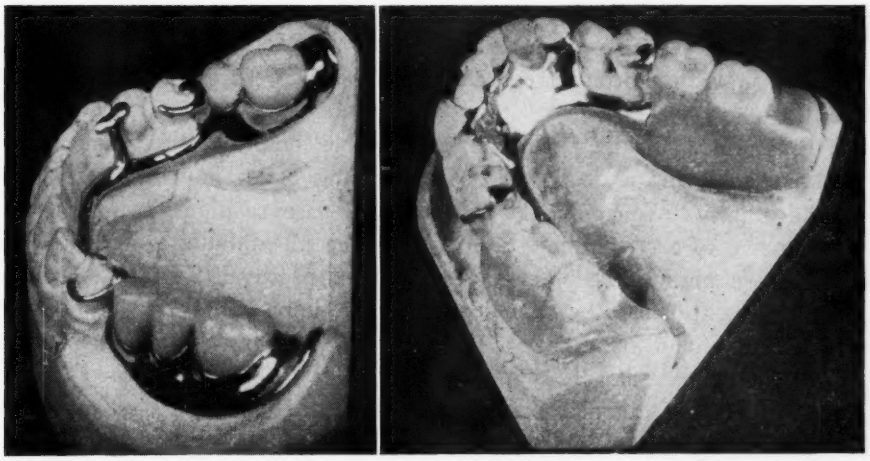

Fig. 1.—These are typical partial dentures (Kennedy Class I). Their major support is derived through the bases which are covering the maximum area of the residual ridge tissue. This means that the borders are located at the line of beginning flexure when the surrounding tissues are extended as in vigorous functional action. The right and left abutment teeth not only supply a minor support but also stabilize against lateral appliance movement, as well as to provide retention against vertically displacing forces.

Figs. 1-10 from Applegate, Oliver C., Essentials of Removable Partial Denture Prosthesis, W. B. Saunders Co., 1954.

Fig. 2.—The removable prosthesis shown in each of these illustrations derives all support from the teeth which serve as abutments. Here the bases *give* support to the supplied teeth, but receive none from the tissues subjacent to them—these appliances are *tooth-borne.*

a poorly adapted base; a base that has undergone volumetric distortion during or after processing; or the commonly occurring situation where the residual ridge tissue has resorbed so that it no longer provides positive support for the base. Not infrequently a combination of some or all such conditions may be noted in the same case.

The first move to assure a stable base which will be kind to its supporting tissues should be taken during mouth preparation. At this time rough spots in the bony process should be smoothed and hyperplastic tissue reduced to provide a ridge that not only will assure greater comfort, but will lessen the displaceability of the supporting tissue. Limited surgical correction may easily make the difference between a base giving lasting and comfortable service and one which may soon cause trauma and destruction. Many dentists are negligent about making these important preparatory changes before beginning partial denture service.

With the residual ridge put in the best possible condition, the second important step toward achieving a good base is the making of an impression registration of the ridge form. What should be the tissue-base relationship which will be most conducive to a continuing state of tissue health and the reduction of ridge resorption to a minimum? One most important prerequisite is that the tissue-borne partial denture base be extended to the maximum area of coverage. Maximum extension should be interpreted as that which is just short of the peripheral line of tissue movement. Extended coverage by the base not only assures a greater total support but also reduces the chance of traumatization and atrophy due to localized trauma.

A second desirable characteristic of the free-end base is that its relationship to the ridge tissues be such that the work load is distributed as uniformly as possible. This will help to avoid the possibility of overwork from localization of stresses on only the firmer areas of ridge tissue. At the same time, another advantage is achieved in that the more displaceable areas will then receive some work stimuli. The latter is most desirable when tissues are covered by a base, thereby being denied contact and thermal stimuli which would otherwise have reached them. When such relationship of the base to its supporting tissue is achieved, both of the undesirable conditions, overwork and underwork, will be avoided.

In this connection it should be re-emphasized that "compression" of displaceable tissue cannot be tolerated. Even in areas which might be termed "soft tissue," only slight displacement should be allowed. Such alteration of form must not exceed physiologic limits, which may be described as that degree of displacement which does not result in surface ischemia, or blanching of the tissue, when the base is in a rest relation with the teeth not receiving any occlusal pressure. We may envision the ideal tissue-base relationship as one in which a maximum area of ridge tissue can make supporting contact with the base; a contact that *during rest periods* will induce no pressure sufficient to cause remaining islands of blanched tissue; so that, under a work load, all of the supporting surface will be receiving work stimuli, but so dispersed that the firmer areas will be spared any trauma from overwork.

During a period of applied occlusal load, surface circulation beneath the free-end base is interrupted and the supporting tissue becomes blanched—a condition of ischemia develops. In the most desirable tissue-base relationship, this ischemia is extended widely and uniformly, not being localized in a few areas. This

blanching is not an undesirable occurrence so long as it terminates *when the occlusal load is removed.* On the contrary, temporary ischemia is but a phase of tissue massage, to be followed, when the occlusal impact terminates, by an influx of arterial blood with new building elements. Indeed, subjacent tissue tonus is so dependent upon this work stimulation as to necessitate a tissue-base relationship which will produce this condition of intermittent massage.

IMPRESSIONS

How can an impression for a free-end partial denture base be obtained so that these conditions are routinely assured? Perhaps the best approach toward an analysis of this problem would be first to note the requisites for an impression of the arch requiring a base of this type. In the first place, the form and relationship of the remaining teeth must be accurately recorded, with the anatomic form of teeth and tissues being registered with exactness (Fig. 3, left). Second,

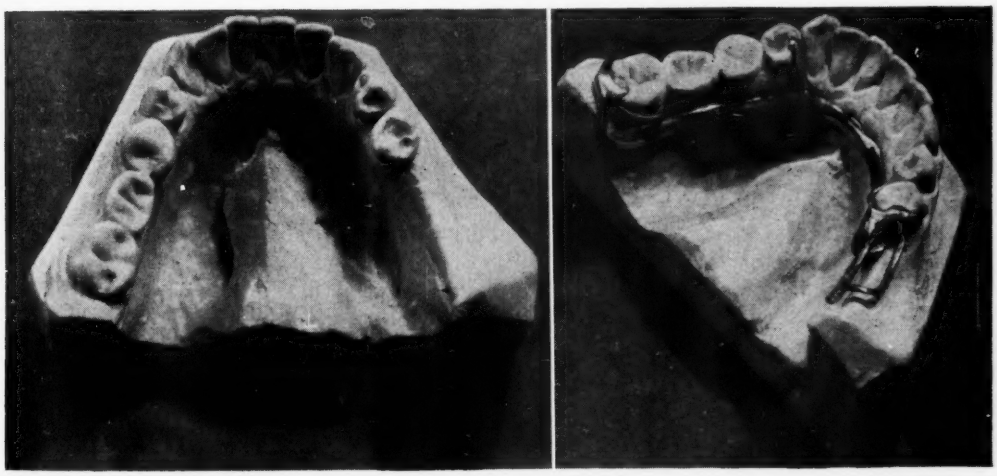

Fig. 3.—A master cast made from a hydrocolloid impression is shown on the left. Accuracy of the form and relationship of the teeth can be readily achieved to permit the making of a cast appliance which will position without pressure upon the teeth (right). However, the tissues which attach to the edentulous ridge may have been distended by the oversize tray beyond the line of their beginning movement. Bases made on such casts will be found to cause peripheral soreness more frequently.

the supporting form of the ridge tissues should be recorded in such a way as to indicate the maximum area of the base, and with the greatest uniformity of work distribution. Of the impression materials presently available, the elastic substances (agar and alginate hydrocolloids) best satisfy the first requirement. Either the reversible agar or the irreversible alginate impression materials will remove from tooth and tissue undercuts without permanent deformation. With these, an accurate cast can be obtained for making the metal portion of the appliance so that it will contact the remaining teeth without exerting any pressure which would cause their movement (Fig. 3, right).

To meet the second requisite, the use of a correctible impression material is most desirable. With either of the hydrocolloids, there is not sufficient time

to have all peripheral tissues undergo complete movement before the gelation of these materials begins. Neither can such movement be fully completed because the margins of the tray would interfere in some one or more areas. This is the more likely to happen in the impression of the partially edentulous arch because of the necessity of using an oversize tray in order to provide adequate thickness of the hydrocolloid in the more severe areas of undercut which are routinely present in these cases (Fig. 3, left). In some, there will even be marginal interference from the oversize perforated tray sufficient to cause severe tissue impingement. This is not an uncommon occurrence in the retromolar region of the mandibular arch.

One excellent reason for desiring a correctible impression of the base area is that a more equitable distribution of the work load to the underlying residual tissues may be accomplished. If the hydrocolloid (or plaster) is quite fluid, there will be no displacement of the soft tissue areas, with the result that the firmer areas will do practically all of the work of supporting the base, while the more movable structures may lose tonus because they receive little or no work stimuli. On the other hand—trying to avoid the above situation—if a thicker mix of hydrocolloid is used, there is the danger that gelation may already have begun, and that overdisplacement of the softer tissues might then result to a degree that pressure trauma would be caused by the base. For these and other less important reasons, the hydrocolloids are less desirable for registering ridge tissues which are to support the free-end base of a partial denture.

Turning to the thermoelastic materials for a possible solution of this impression problem, there are available the modeling compounds and waxes. Both of these materials have been used extensively in correctible impression procedures. Certain difficulties that will be encountered in the use of modeling compounds should be noted, since they are especially prone to occur in the type of impression now being considered. First, and perhaps the most serious, is the great difficulty of definitely controlling the degree of tissue displacement which may result where an attempt is made to alter an area of a compound impression. The amount of flow of modeling compound depends on the degree to which it is softened by warming. This is a step which is exceedingly difficult to control when correction of an impression is attempted. The most common fault is that overdisplacement of movable tissue may be caused, especially in the hands of the beginner. Modeling compound is used frequently in conjunction with a special impression wax which has been given suitable physical properties, particularly an increased flow at body temperature. In this combination, the modeling compound really serves only as a tray. The difficulty of placing the tray compound, and later removing it from the appliance framework, has caused many to discard it in favor of an extra hard wax. This wax is formulated to serve specifically as a tray material, reinforcement being provided by the metal framework (Fig. 4, left). It can be flowed or painted on the lubricated cast—under, around and over the metal framework (Fig. 4, right). It can be removed easily from a prepared cast; can be worn without distortion; is sufficiently strong

to support any slight peripheral extension of the impression wax; and later can be flushed cleanly from the framework with boiling water. Activated resin placed over and around the metal as a tray for the impression wax has the advantage of being strong with less need for metal re-enforcement, but it requires more time to place and may be more difficult to remove. The all-wax method seems preferable, particularly since the tray wax can be so easily re-enforced by letting a small loop of a heated paper clip melt into the outside surface.

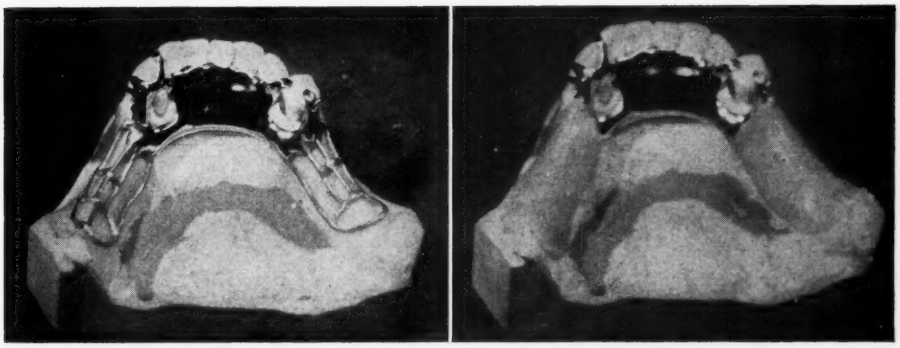

Fig. 4.—The cast framework of this partial denture will be used to carry and support the correctible wax impression of the residual ridge area. On the left, the appliance is seated on the cast. The wrought clasps are now adapted, the relief wax removed, and the cast lubricated. On the right, the hard tray-wax (Korecta-wax No. 1) has been added while very hot to flow under and around the supporting metal framework. The finished impression carried in this tray may be seen in Fig. 5, left.

A special series of waxes to be applied in fluid form were developed in 1930 through the cooperative efforts of Drs. George C. Bowles, S. G. Applegate of Detroit, and the author. Some two hundred formulas were studied clinically and in laboratory tests, and from these, four were chosen, each having a special use. Usually only two are needed in registering the supporting form of the edentulous ridge tissues, the re-enforcing or tray wax (No. 1) and the impression wax (No. 4). This series was given to a manufacturer equipped to properly maintain constant physical properties, and was made available in 1935 as the Kerr Korecta-wax series. The rate of flow of the impression wax (orange, No. 4) is a very important factor in obtaining the desired tissue-base relationship by this method of impression registration. Severe tissue trauma from overdisplacement can be caused by allowing a small portion of the very hard wax (pink, No. 1) to become mixed into the impression wax—contamination, therefore, must be avoided. A single wafer of each wax should be melted in a water-bath type of heater; applications are made with a small stiff brush.

Time does not permit a detailed review of this correctible impression method, but certain reference to the published[1] account will emphasize the ideal way in which it can be applied to accomplish the desirable tissue-base relationship described above. There are several advantages of wax for registering the tissue form in making an extension type partial denture base. In the first place, a *supporting contact* with the subjacent tissue can be easily determined—the im-

pression surface becomes glossed (Fig. 5) with a shiny, instead of a dull or frosted, appearance. Second, the *maximum area* of the base is plainly delineated by having the peripheral tissues exercised to show the line of their beginning movement. Since the necessary additions of wax can be made where a dull area indicates lack of support, or on a border where no turn is in evidence, this method is correctible to an unlimited degree (Fig. 5). Finally, it is quite easy to avoid overdisplacement of tissue by this registration method—the impression is simply retained for an adequate time (5 to 15 minutes) with the supporting framework or the resin tray seated definitely on the remaining teeth. Any excess wax escapes to the periphery, and by an intermittent exercise of the adjacent tissues its marginal length and contour is perfected (Fig. 5).

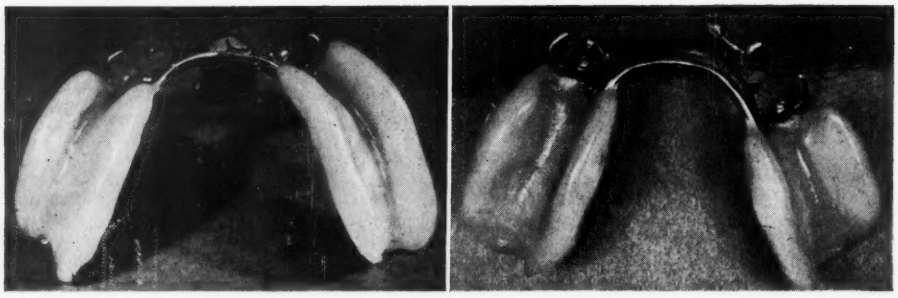

Fig. 5.—Completed impressions of the edentulous areas which are to support partial denture bases. Only tested impression wax should be used since it must have a constant flow at body temperature. This flow must be enough to permit the escape of any excess in order to avoid overdisplacement of tissue. However, all tissue covered by a base must receive stimuli in order to retain good tonus. The form of the soft tissue area should be modified just slightly—it should be so related to the base that it is *ready to begin supporting.*

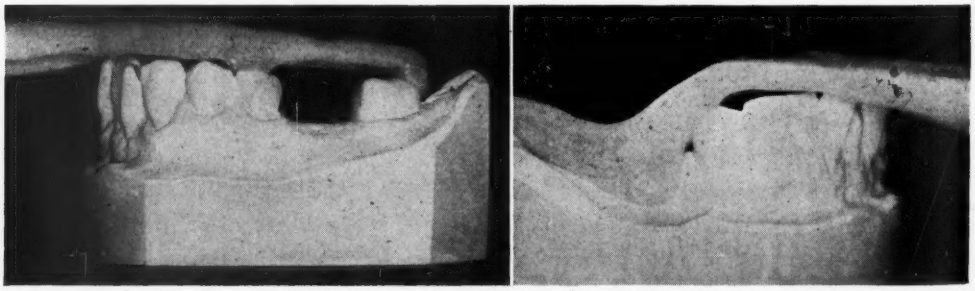

Fig. 6.—The right and left views of a resin tray which is to carry an impression of the right edentulous area. Note that the resin has been ground to a line contact in the stop area on the right first bicuspid (right view). Similar stops have been prepared on the left second bicuspid and molar teeth (left view). Three well-separated stops provide the same definite relation of the tray to the teeth in the mouth as on the cast.

The use of the partial denture casting to which a hard wax base is added (Fig. 4) has been mentioned as a method of accurately positioning this impression. Another very dependable way is to make a resin tray,[2] having a definite stop on each abutment tooth and a third support midway between (Fig. 6). Of

course, this procedure is contraindicated where only a few teeth remain (as in a cuspid-to-cuspid situation) so that the three stops cannot be widely spaced. The resin tray method of obtaining a correctible impression is particularly useful when a metal base is desired. By removing the ridge portion of the master cast, the resin tray carrying the new wax registration is seated (Fig. 7), and the cast corrected (Fig. 8). This permits the casting of the base with the other metal units of the appliance, eliminating any necessity of assembling and soldering. The appliances seen in Fig. 9 were constructed in this manner. Since the peripheral tissues were permitted to record their line of beginning movement, no marginal adjustment of this partial denture base was necessary; it has retained perfect stability and the tissue tonus is excellent.

Fig. 7.

Fig. 8.

Fig. 7.—The ridge area of the cast has been removed and the resin tray seated accurately in the stop areas. The tray should be luted securely, but this should be done in places other than the stop areas. By leaving the relation visible at these places, its accuracy may be checked during the steps of adding the new form of the ridge.

Fig. 8.—The corrected master cast after the removal of the impression seen in Fig. 7. Note that both the length and peripheral thickness of the flanges is now definitely indicated. This assures maximum appliance stability with least possibility of postinsertion adjustments because of peripheral irritations. It is possible to see the line of union of the new ridge with the original cast just posterior to the abutment. In this way the tissue area of the ridge is given a *contact* relation to the base with the occlusal rest preventing impingement.

PARTIAL DENTURE BASE MATERIALS

The material of which the free-end partial denture base is constructed may definitely influence the length of satisfactory service given by the appliance. The search for an ideal base substance began with the early use of bone or ivory which was crudely carved to fit the ridge tissues, in the first efforts to replace lost teeth by means of a removable substitute. In earlier attempts (antedating Christ), metal was used to support replaced teeth, but these appliances were not removable. That this quest must continue still further, if an ideal base is to be obtained, seems evident when the requisites of this type of base are critically evaluated. Even an abbreviated list of these should certainly include the following important qualities: First, the base material should permit accuracy of tissue adaptation. This means that there should be no volume change during its processing and that the base must not distort in usage. Unless it is possible to maintain a stable partial denture base, the prevention of tissue trauma is utterly impossible. The urgency of this requisite places it first in a list of qualifications—it is imperative. Secondly, the surface of the base must not irritate the tissues.

This requires that it be dense and capable of receiving and retaining a good finish. If it has a low sorption of oral fluids, it will retain less debris which might also promote chemical and bacterial irritation. These essentials have been directed chiefly toward avoiding tissue injury, but it is quite as urgent to promote tissue tonus. So a third quality of the ideal base should be that of being capable of thermal conductivity. The importance of having the base transmit a uniform load of work stimuli to the subjacent tissues has already been noted. However, the benefit of such massage may be augmented in a valuable way by thermal stimuli which may be conducted by the base. The effect produced will be much the same as that resulting from the intermittent application of reasonable work loads. Contacts of hot and cold food and drink against a conductive base causes the surface arterioles of the underlying tissue to expand and contract, encouraging the flow of tissue fluids as in massage. This value of the conductivity of a basal material has long been recognized, but a virtue of the conductive base which has not received adequate mention is that in this way an *escape of body heat* from the subjacent tissue is provided. Failure in this latter respect is a serious deficiency in the partial denture base.

This base should possess another important characteristic—low specific gravity. Reduction of the appliance weight is more urgently required for the maxillary partial denture. In this situation, gravity exerts a constant pull, tending to unseat the free-end base when the teeth are out of occlusal contact. This normally would be all but a small percentage of the time. The resulting strain on the structures which support the abutment teeth will be directly proportional to the appliance weight and length, since the principle of leverage will be operating.

While avoiding heavy substances for the base, it is desirable to select one having sufficient resistance to surface abrasion. Reduction of the supporting surface in this way would impair the stability of the base in direct ratio to the degree of its destruction. Overzealous brushing with abrasive powders by an enthusiastic but uninstructed patient may produce this amount of wear in a relatively short period. There is little doubt that what is often interpreted as alveolar process resorption is actually, to a considerable degree, a loss of substance from the base. It should be recalled that even if such abrasive change were to occur on only a portion of the supporting base, the tissue underlying the rest of its surface might then be overworked, with atrophy being induced to further diminish the stability of the base. In this connection, the use of a detergent solution for the cleansing of a removable prosthetic appliance is strongly urged.[3] An appliance can be kept perfectly clean without being subjected to the danger of damage from abrasive substances or brushes. If a fresh, warm solution of a detergent is used each time the patient brushes his remaining teeth, it will remove surface films of debris which have clung to the appliance. In turn, the deposition of calcified deposits will be less likely in the absence of surface film. However, when deposits of calculus are observed on the removable denture, they also may be detached without abrading its surface by the use of a warm solution of dilute acetic acid as a supplemental cleansing aid. This may be made conveniently by diluting a little household vinegar in warm water. This procedure usually will be required at infrequent intervals, if at all.

The matter of esthetics should not be ignored in recounting the properties of the ideal denture base. Not only is it an advantage to use a material which has pleasing color and natural appearance, but it is often necessary to use it to support the tissues to produce a more normal facial contour. This will be especially urgent when there has been excessive loss of alveolar structure through disease or accident. Such a situation will call for use of considerable bulk of base material in some cases and, in the maxillary arch, will again present the problem of controlling the appliance weight.

Thus, it is seen that the ideal base material should have no uncontrollable volume change during its processing, or warpage in later use; its water sorption rate should approach zero; it should have high thermal conductivity and low specific gravity; and it should not be easily abraded in a rational method of cleansing. In addition to these urgent requisites, it will be an added advantage if the base is such that it will not be injured by more extreme temperature changes to which it may be accidentally exposed; it must withstand reasonable forces during function and, also, if possible, those resulting from an occasional accident of being dropped; in addition, the partial denture base should be of pleasing appearance; it should be capable of being easily rebased or repaired, and, finally, the initial and maintenance cost should be such as not to limit its wide usage.

There are two classes of materials which are, at present, widely used for the construction of the partial denture base. These are resin and metal, in the order of their present application for the construction of this extension type of base. It is immediately apparent that neither one of these fulfills all of the above-listed requisites for an ideal base. Some metal alloys may be objectionable because of their greater weight; because of the increased cost of producing a metal base; or because metal has a low esthetic value if the base is of the type that will be displayed. The most serious disadvantage of the metal base, however, is that it is extremely difficult (if not impossible) to reline it, should there be a need for this reconditioning as a result of residual ridge resorption. However, offsetting this objection in some degree, the first advantage of the metal base to be noted is that there will be less need for its correction by relining. This is due to the added stimulation of the covered tissues by the metal base which cannot be provided by the less conductive resin. Thermal shocks are conducted to the tissue by the metal base alternately expanding and contracting the surface vessels, not unlike the effect of massage. This phenomenon, and that of providing for the ready escape of body heat away from the covered tissues, produce the best possible tissue tonus. These conditions are most likely to maintain the ability of the residual structures to support the base in the most stable manner. It is the conviction of the author that in more than half of the borderline cases, where one might hesitate to utilize a free-end metal base (fearing later resorption), the added benefits from the metal may actually prevent the need for the subsequent relining which would have been necessary if resin had been used. However, when favorably considering the use of metal, one pre-

caution cannot be too strongly emphasized. If the teeth have been missing for a long time from the area which is to support a free-end base, the alveolar bone may have undergone structural change due to its lack of use. Until there has been trabecular rearrangement and growth in response to the new functional stimuli, it is very possible that some further resorption of the subjacent tissues may occur. In fact, there is a greater probability of this change taking place in an area which has *not been used* than in one from which the teeth have just been extracted but which has received work stimuli through teeth which were in occlusal relation until that time. Hence, the use of the metal base is always safer where there has been a previous record of a partial denture base having received stable support. Since a relining procedure will be needed in a certain percentage of cases soon after placing the extension base, there is good reason to use resin for its construction because it is more easily corrected.

There is definite limitation, then, in the use of metal for the free-end partial denture base (Fig. 9). The indications for its use are: first, where there is ample evidence of good alveolar resistance to heavier-than-normal stress loads, but where the edentulous ridge has not been out of function too long; second, because of its maximum strength with minimum bulk, the metal base is indicated where there is a serious reduction in available tongue or tooth space due to a loss of vertical opening; finally, the choice of metal is clearly indicated in modification spaces where the base will be completely tooth-borne (left side of Fig. 9, center).

Resin possesses properties which have made it one of the most useful in a long list of substances attempted in denture base construction. Without question it ranks topmost in esthetic value—first, because it simulates oral tissue so remarkably well and, second, since it undergoes such slight color change as it is worn. Another advantage of this material is that it can be processed or repaired so simply that its original or maintenance cost brings its usage within the reach of those who are economically restricted. Even though a large quantity of resin may be required in order to build out the facial tissues to the desired contour, there is, because of its low specific gravity, no resulting problem of weight. Another quality in which resin outranks metal is that of being easily and economically altered, as when the base needs to be readapted to an altered ridge form (Fig. 10). This permits the maintenance of a partial denture base in the proper tissue relationship at only a small portion of the cost of a complete replacement of the prosthesis.

It is indeed with a tinge of disappointment that one must record some poor qualities of resin as a basal substance. At this point in its development, resin is not completely stable, being subject to volumetric change as it is being cured and possible warpage as it is being worn. Happily, these changes are quite limited in the partial denture base, because it is re-enforced by the metal casting, and so in this phase of dental prosthesis the volume change in resin is of relatively minor concern. A much more serious problem is the control of abrasion in the resin base of a partial denture. As has been pointed out, this can lead to very serious complications since the partial denture is a destructive lever if the base

Fig. 9.—Metal bases cast to corrected ridge areas. The resin tray method of procuring a correctible impression of the residual ridge is of much advantage when a metal base is desired. With an exact means of determining maximum base extension, it may be cast with assurance that minimum correction will be needed.

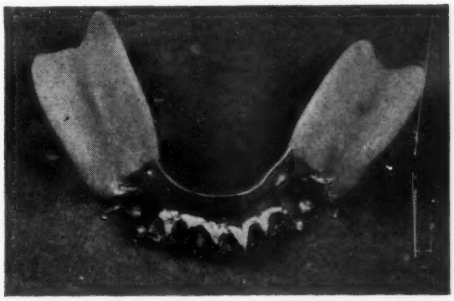

Fig. 10.—This partial denture has been relined to re-establish the proper relationship of the base to the ridge. A very important advantage of the resin base is that this correction can be done with exactness and at minimum cost.

becomes unstable and can move excessively. But here also, there is hope of circumventing this inherent weakness of the resin base by care in cleansing it as has been discussed above.

Another respect in which resin is much inferior to metal (particularly for the type of base now being considered) is that it possesses extremely poor thermal conductivity.[4] It has, in fact, almost an insulating action which seriously prevents the escape of body heat from the underlying tissues. This tends to lower the tissue tonus of these structures. Thus, where the induced stress load is already close to the limit of physiologic tolerance, the entrapment of body heat may be sufficient added cause to promote tissue resorption. Low thermal conductivity, therefore, may be a serious defect in the base for the free-end partial denture, because so frequently the margin of tissue tolerance is very slight in these cases.

In conclusion, no unit can have more bearing upon the success or failure of the partial denture than its base—it is in fact the foundation. As such, we should give it the thoughtful study and meticulous execution which it deserves.

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A SYSTEM OF MODIFIED ATTACHMENTS FOR REMOVABLE PARTIAL DENTURES

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REMOVABLE APPLIANCES bearing clasps which come in contact with tooth enamel are not only unesthetic but they promote caries and periodontal lesions. With this system, all abutments are prepared for restorations (inlays or crowns, etc.) which in turn have slots for a male counterpart and also a groove on the lingual surface for the retention clasp.

When the appliance is firmly seated, both the retention clasp and the attachment form a rigid unit. The function of the attachment is to maintain the tooth in its proper position, and as an opposer to the lingual clasp.

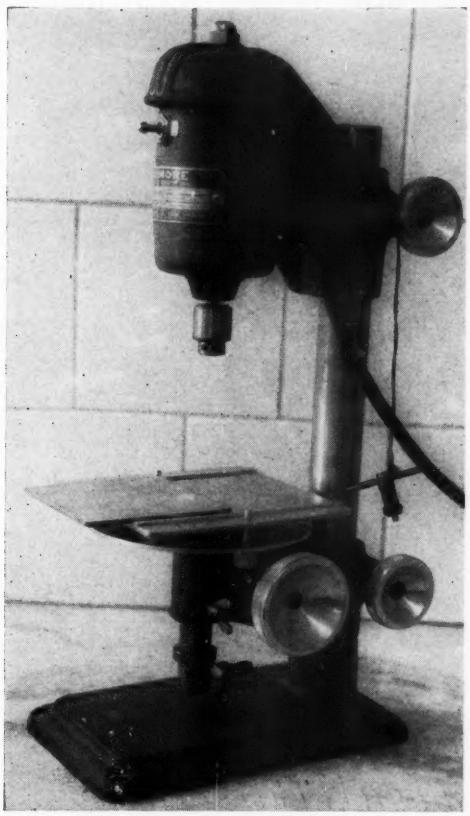

Fig. 1.—The drill press which is used to parallel the slots in the patterns for the restorations.

Read before the First International Odontological Congress, the Fifth Brazilian Odontological Congress, and the Second Pan-American University Odontological Congress, S. Paulo, Brazil, Oct. 25-30, 1954.

Received for publication Jan. 6, 1955.

NECESSARY REQUISITES

1. A drill press of absolute precision (Fig. 1) is used (a) as a surveyor, (b) for the insertion of graphites previously covered with platinum foil 0.001, or for inserting the trays made of platinized gold, and (c) to rectify and polish the slots.

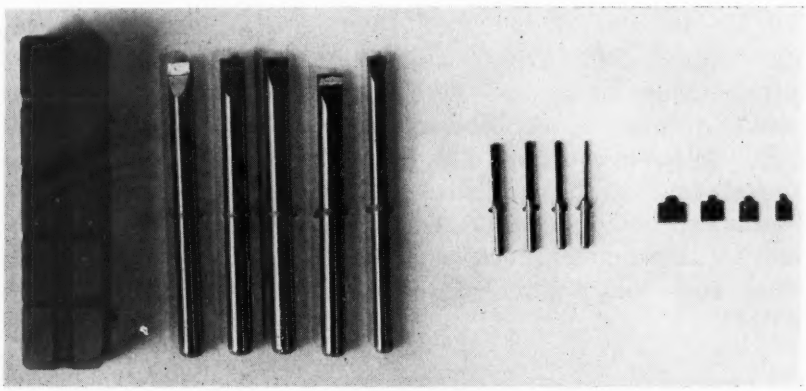

Fig. 2.—Punches used for making the platinized gold matrices.

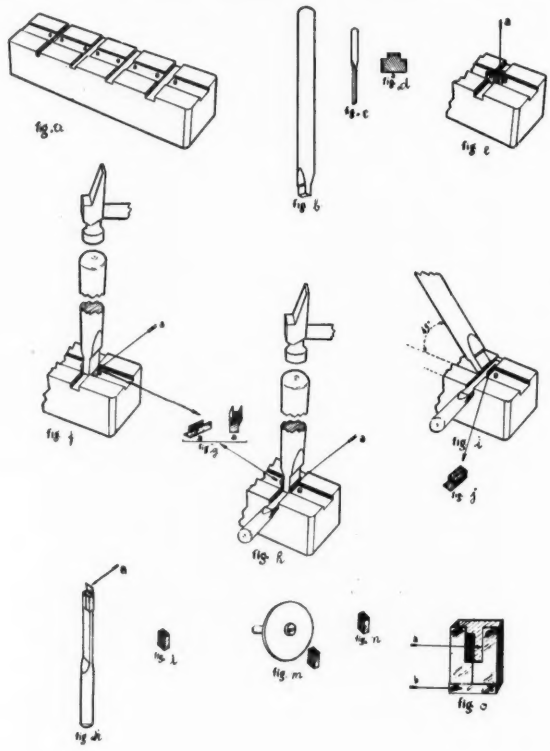

Fig. 3.—Equipment for making the trays.

2. An instrument is needed to make the trays (Fig. 2); also a die with a series of matrices of the following sizes in millimeters: 1 x 2, 1.5 x 2, 1.5 x 3, 1.5 x 1.5.

With punches and matrices, the trays are made of platinized 30 gauge gold (0.25 mm.) (Fig. 3.) Once the matrices are chosen (according to the preparations on the abutment teeth), the trays are made and then placed on the perforating machine for correct placement in the waxed-up restorations.

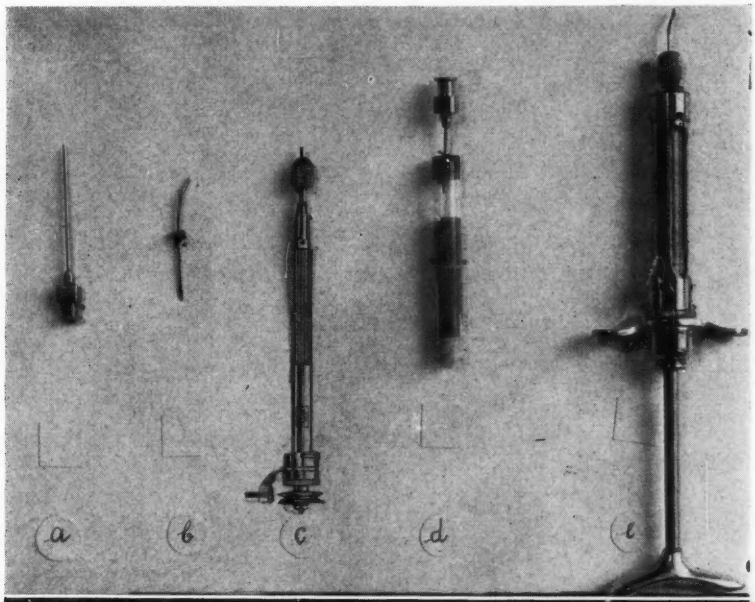

Fig. 4.

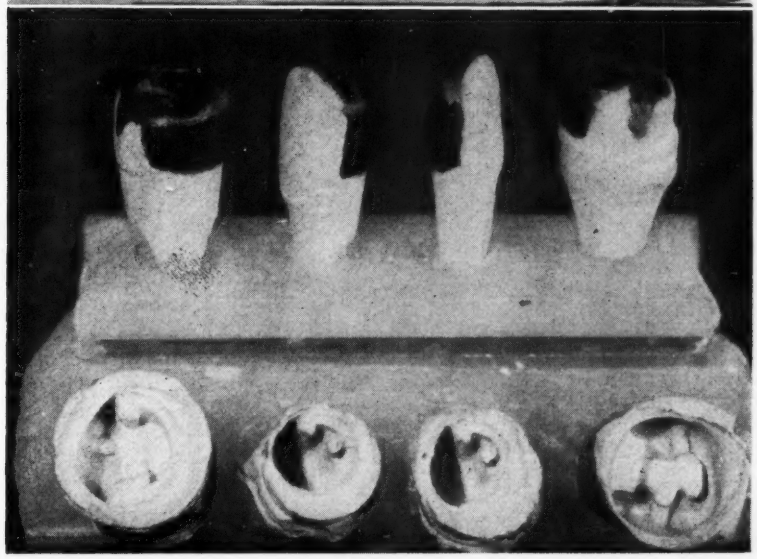

Fig. 5.

Fig. 4.—Syringes for making hydrocolloid impressions of the prepared abutment teeth.
Fig. 5.—The impressions, the dies, and the wax patterns.

TECHNIQUE

After all preliminary examinations have been made, the abutments are prepared for inlays or crowns.

1. Impressions of the prepared teeth are made either in a hydrocolloid material using a special syringe, or a common syringe using a 40 x 10 needle (Fig. 4), or with copper bands using an impression compound which has a synthetic rubber base (Fig. 5). Over these an impression of the entire arch is made, and the restorations are carved on the articulator.

Fig. 6.

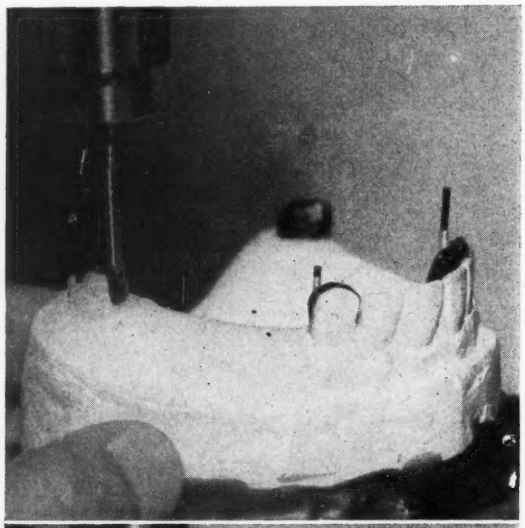

Fig. 7.

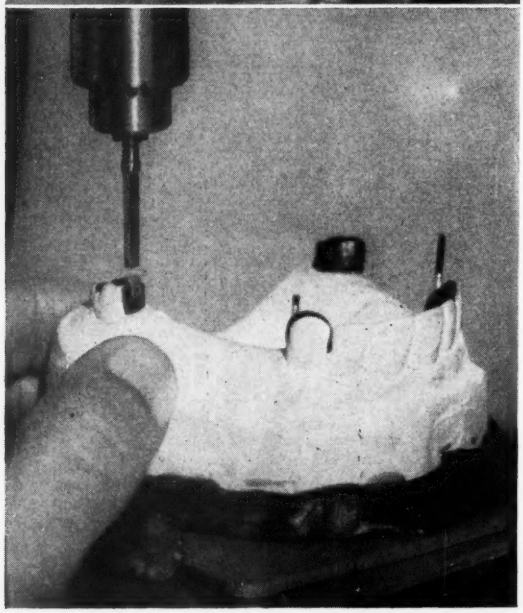

Fig. 6.—The cast is positioned with wax on the drill press for paralleling the platinized gold trays or graphites for making the slots in the abutment restorations.

Fig. 7.—The trays are placed in position.

2. a. The cast is secured to the base plate of the drill press with wax, and the positions for the trays or graphites are determined (Fig. 6).

b. The position for the trays or graphites having been determined according to the long axis of the abutment teeth, the cast is secured to the base plate with

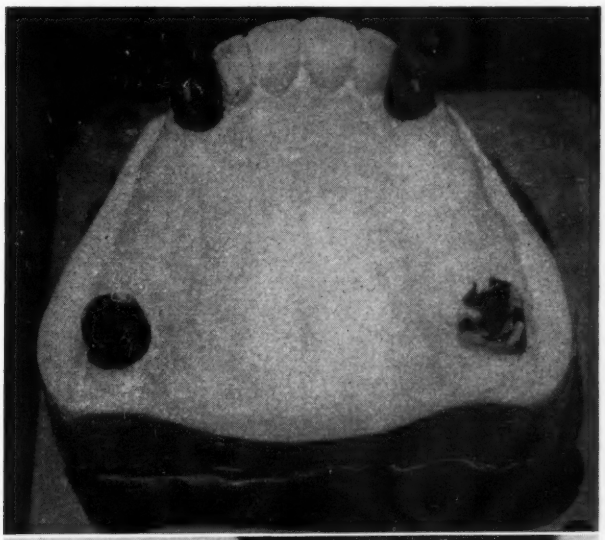

Fig. 8.

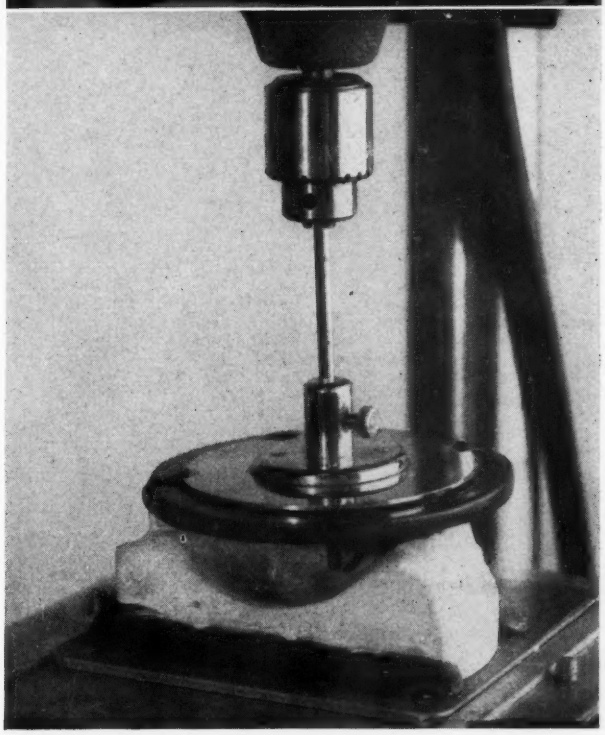

Fig. 9.

Fig. 8.—The cast with the abutment patterns and the trays in position.
Fig. 9.—The device for recording the line of insertion of the partial denture. It is parallel to the long axis of the trays in the abutment restoration patterns.

sticky wax. Slots are made in the waxed-up restorations for the trays with burs on the drill press or spatulas.

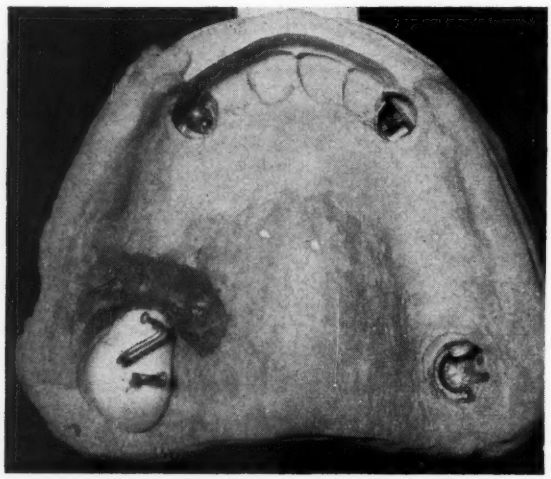

Fig. 10.—The full plaster impression for making the master cast. The castings are in place.

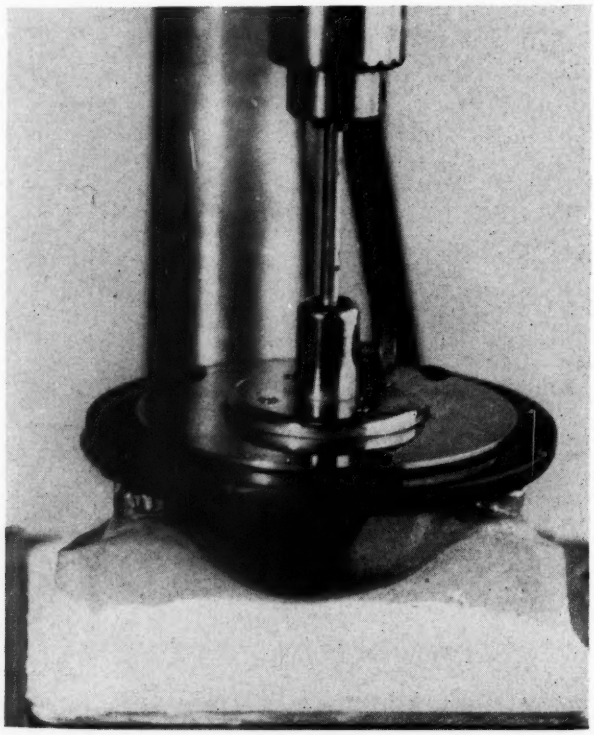

Fig. 11.—The master cast is repositioned exactly as was the preliminary cast by means of the positioning record. The master cast is remounted in this position on the drill press with plaster.

c. The position for each restoration having been determined, the cast is immobilized by securing the base plate to the base of the drill press with wax. The trays are then placed in position (Figs. 6 and 7). Fig. 8 shows the cast with the trays and graphites inserted in the wax restorations and perfectly parallel.

3. The waxed-up restorations are removed, and a record is made of the position in which the trays were inserted (Fig. 9). (Collaboration of Dr. Arildo Gonçalves.

4. The waxed-up restorations are checked on the teeth. This step can be dispensed with if the indirect technique is used.

5. The restorations are cast and polished. The slots are left untouched.

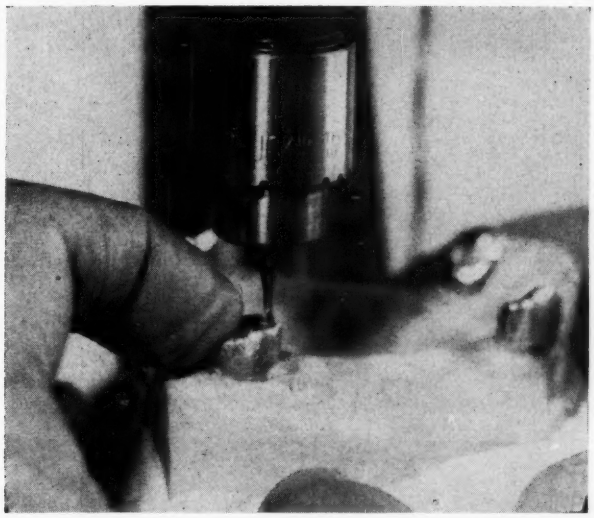

Fig. 12.—The slots are perfected by means of a bur in the drill press.

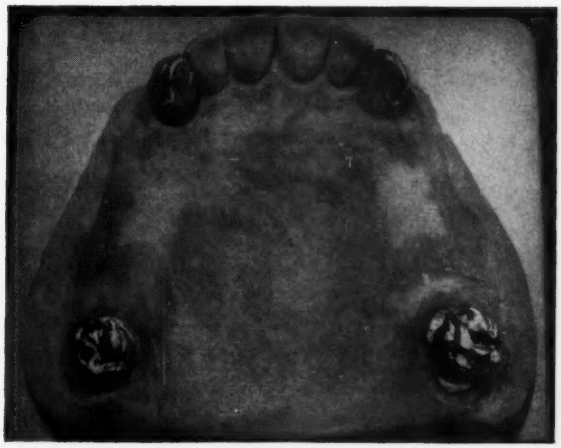

Fig. 13.—The master cast with the restorations in place.

Fig. 14.

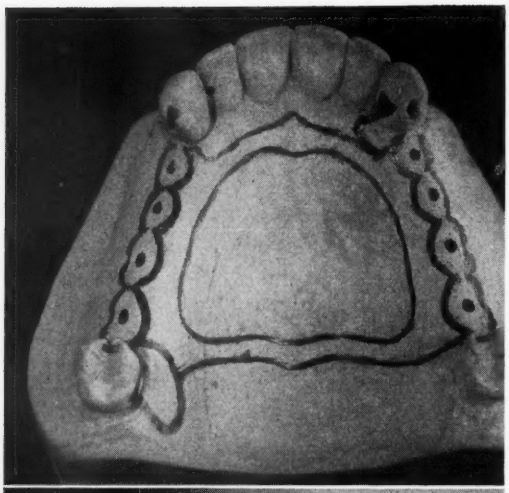

Fig. 15.

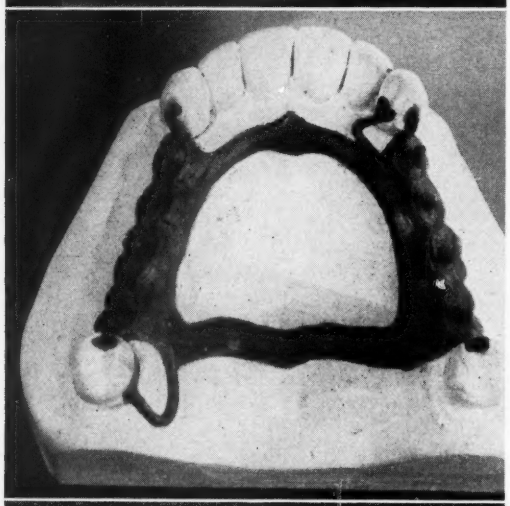

Fig. 16.

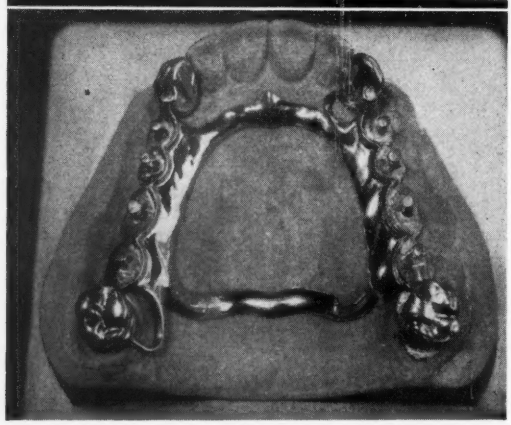

Fig. 14.—The outline of the casting on the refractory investment cast.
Fig. 15.—The wax pattern for the casting on the refractory investment cast.
Fig. 16.—The casting in position on the master cast.

6. The restorations are tried in the teeth in the mouth, and an impression is made in plaster.

7. a. The impressions of the abutment teeth are poured in metal (Fig. 10), and the remainder of the impression is poured in stone. This constitutes the master cast.

b. The master cast, without the inlays, is now secured to the base plate of the drill press with wax. It is then positioned to coincide with the register previously obtained (see Fig. 9). Once in position, the cast is secured with plaster (Fig. 11).

8. a. The slots are trimmed and polished (Figs. 12 and 13).

b. The undercuts are filled in, and reliefs are made on the master cast. The cast is duplicated and poured in a refractory investment material (Fig. 14).

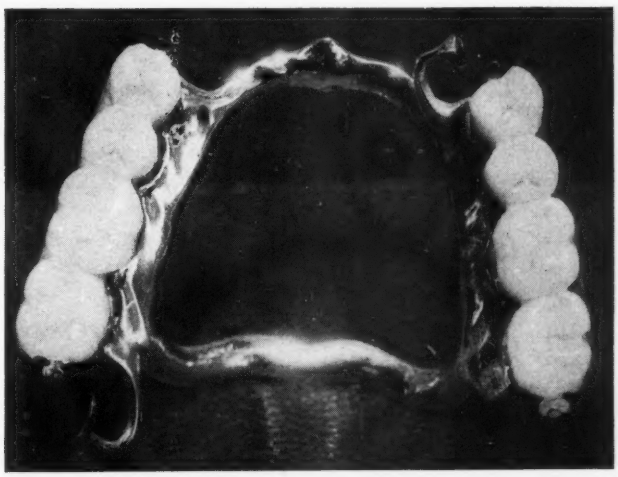

Fig. 17.—The completed restoration.

c. On this refractory investment cast, the grooves for the lingual clasps are touched up.

d. The pattern for the casting is waxed up (Fig. 15), cast, and polished. It is then adapted to the master cast (Fig. 16).

e. The teeth are set up and tried in before the final polishing (Fig. 17).

9. The appliance is inserted. The restorations on the abutment teeth are cemented one at a time, with the remaining restorations in their positions. The appliance is tried in after each cementation.

CONCLUSION

This technique dispenses with connectors proper and soldering. Repairs are easily performed. If copper-plated dies are used, all the work can be done by the indirect method.

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ACRYLIC RESIN TRAY FOR RUBBER BASE IMPRESSION MATERIALS

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THIS IS A DESCRIPTION of the fabrication of an acrylic resin tray and the technique used in making impressions for fixed bridgework and crowns. The technique has been in use in the Crown and Bridge Department, University of Alabama School of Dentistry, during the last several months. Many methods were attempted before the one described in this article was finally chosen.

Since rubber base materials, if manipulated and handled properly, have certain advantages over other elastic impression materials, it was believed that an individually constructed tray for each patient would utilize to the utmost the elasticity of rubber base impression materials.

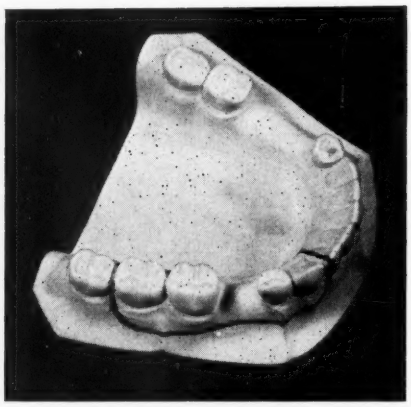

Fig. 1.—A pencil outline of the area which the acrylic resin tray will cover on the study cast.

PROCEDURE

A study cast is outlined with pencil (Fig. 1), and then a strip of narrow soft wax is applied over this pencil line as in Fig. 2, *A* and *B*. The purpose of the wax is to confine the acrylic resin monomer and polymer to a definite area. Fig. 2, *A* also shows the undercut areas blocked out for easy removal of the finished

Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 6, 1955.

Received for publication March 8, 1955.

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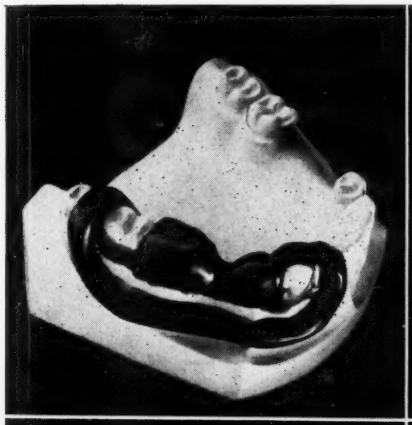
tray from the cast. Blocking out allows for an extra thickness of impression material to prevent distortion during removal from the mouth. Fig. 2, *A* and *B*, illustrates the covering of the abutment teeth (before preparations) with wax approximately 1 to 1.5 mm. thick. The wax also covers about one-half of the approximating tooth, mesial and distal, if present. This thickness of wax acts

Fig. 2,*A*.



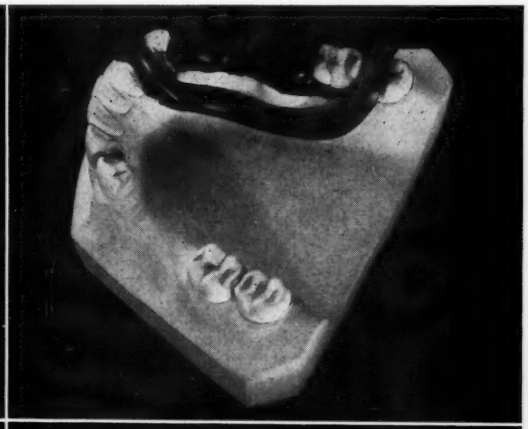


Fig. 2,*B*.

Fig. 3.

Fig. 4.

Fig. 2.—Buccal *(A)* and lingual *(B)* view of wax following the pencil outline to confine the quick cure acrylic resin. Undercut areas are blocked out. Wax covers the teeth before the preparations are made. Areas not covered with wax act as stops on occlusal surfaces, and at the periphery they help prevent the escape of excess impression material.

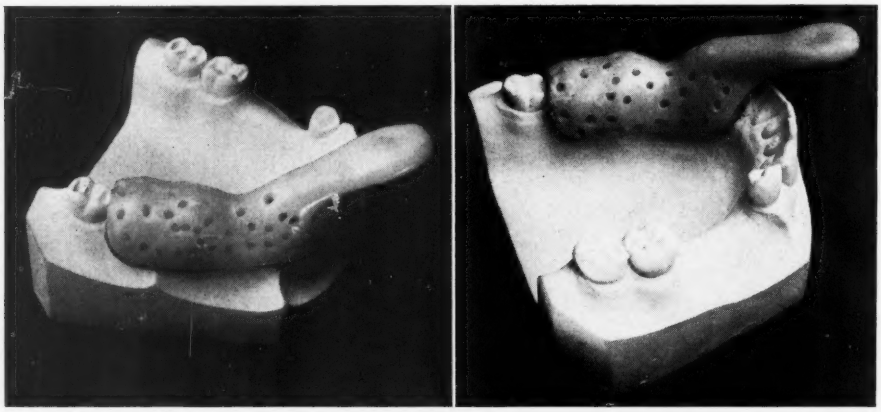
Fig. 3.—The acrylic resin tray is formed by addition of proper amounts of polymer and monomer.

Fig. 4.—The acrylic tray is formed, and the handle is added.

as a relief area in the finished acrylic resin tray for additional impression material to allow for better use of its elasticity. As can be seen in Fig. 2, *A* and *B*, there are areas on the cast which have no coverage by the wax for a very definite reason. These are on the occlusal or incisal surfaces, and they act as positive stops for the tray. During impression making, the borders of the tray are in contact with soft tissues and aid in confining the impression material within the tray.

The visible surface of the stone is treated with a suitable separating medium. Quick-curing acrylic resin is employed, and Fig. 3 illustrates the placing of the

polymer and the addition of the monomer until the complete surface is covered, and the handle attached (Fig. 4). The tray need not be more than 1.5 to 2.0 mm. in thickness for sufficient strength. When hard, the tray is removed, and if the undercut areas have been properly eliminated and the raw stone covered with separating media, the tray should come away from the cast with little effort. The tray is then perforated with a No. 8 round bur (Fig. 5, *A* and *B*). As



A. *B.*

Fig. 5.—Buccal *(A)* and lingual *(B)* view of finished tray, trimmed to outline, and with holes cut for retention.

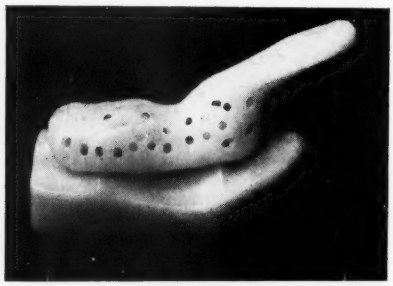


Fig. 6.—The tray in place on the model which represents the oral counterpart.

many perforations as necessary should be made since these holes are the only means of securing the impression material to the tray. Mechanical retention, not adhesion, keeps the impression in the tray. The dentist should be sure to have a number of holes around the border of the tray to prevent the impression material from peeling away in this region (Fig. 6).

Gum retraction is not always necessary when the rubber base materials are used, since they will flow into an existing crevice if no moisture is present. Because of their nature, they will have enough strength to remain attached to the impression, and enough rigidity to remain undistorted if care is used in making the cast.

IMPRESSION PROCEDURE

Before mixing the impression materials, the teeth and soft tissues are isolated with cotton rolls and dried. The tray is checked for fit, and, if satisfactory, it is removed, and the mix is made according to the manufacturer's directions. The tray is filled, and sufficient material to fill the preparations is carried on

Fig. 7.

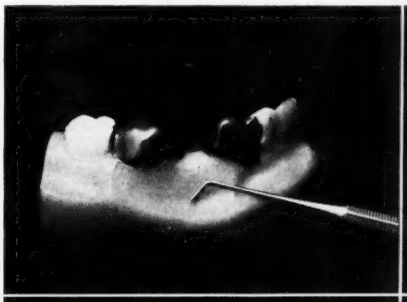
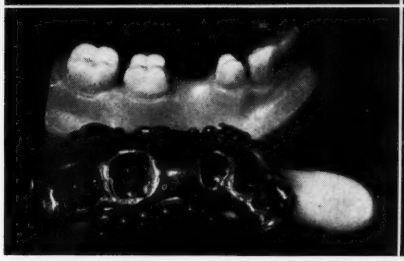


Fig. 8.

Fig. 9.



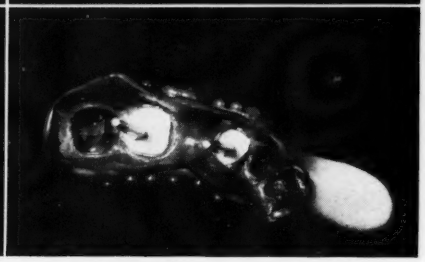
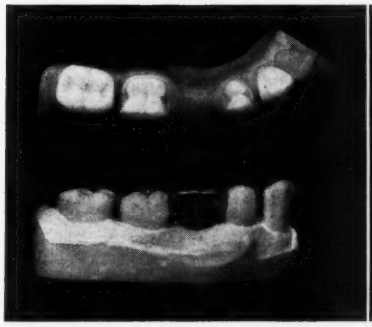


Fig. 10.

Fig. 11.



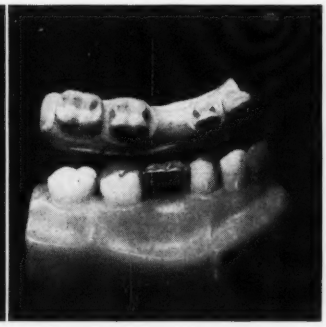


Fig. 12.

Fig. 7.—The rubber base impression material has been placed over the preparations with a cement spatula. The instrument in the photograph is used to carry the material into the grooves and hard-to-reach spaces of the preparation.

Fig. 8.—The tray is in place with the impression locked to the tray.

Fig. 9.—The impression is removed from the model, washed, dried, and inspected.

Fig. 10.—Dies are poured and pins are placed. These dies are removed when they have set hard, and a second mix is made for a solid cast to be mounted on an articulator.

Fig. 11.—The bridge is constructed on the solid cast.

Fig. 12.—The bridge is transferred to the original model representing the mouth. Under low magnification, the fit is as good on the model as it was on the cast on which the bridge was first constructed.

the cement spatula and applied to them. For full crowns, a spatula is usually the only instrument used. For three-quarter crowns or intracoronal preparations, an SSW FP Tarno 3 instrument facilitates placing the material into spaces too difficult to reach with the spatula (Fig. 7). The previously filled acrylic

resin tray is quickly put to place, and held firmly without movement for approximately five minutes (Fig. 8). It should be emphasized that the handle of the tray is used to carry it to place, but not as a lever for removing the tray.

The impression is washed, dried, and inspected (Fig. 9). If satisfactory, the individual impressions of the preparations are poured first with a heavy mix of Duroc stone (5.5 c.c. water to 25 Gm. powder). Ney dowel pins are inserted (Fig. 10), and the impression is allowed to set in a humidor for about forty minutes. The individual dies are carefully removed and inspected. At this stage, the preparations are examined again and, if necessary, corrected at the next sitting. The solid cast is poured with the same water/powder ratio, and the preparations are checked for parallelism. If corrections are necessary, they can be made at this same sitting.

The reason for the solid cast, rather than removable dies, is obvious from a teaching point of view. It is impossible for the uninitiated to replace the removable dies always in their original positions, and this failure introduces errors in the alignment of the finished bridge.

After securing the individual dies and articulating the solid cast, the fabrication of the bridge is carried out in the conventional manner. Fig. 11 shows the bridge as it was constructed on the solid cast. In Fig. 12 the bridge has been transferred to the original model representing the mouth. Under low magnification, the fit is as good on the model as it was on the cast on which the bridge was first constructed.

ADVANTAGES OF THE RUBBER BASE IMPRESSION MATERIAL

1. They are very elastic in nature.
2. They have good dimensional stability.[1]
3. The impressions do not have to be poured within a half-hour, as do the hydrocolloids.[2]
4. More than one cast can be made successfully from the same impression. if care is exercised.
5. Exceptionally smooth dies can be made.
6. Gum retraction is not always necessary.
7. Accuracy is comparable to that of the hydrocolloids.

We believe that the favorable results which we have had in using this rubber base material for impressions is attributable largely to the availability of a well-adapted rigid tray. In conversations with Dr. Stanley Tylman, Professor Ralph Phillips, and Dr. Eugene Skinner, all were of the opinion that rubber base impression materials are as accurate as the hydrocolloids.

Thanks should go to the students who have given so generously of their time and energy to help develop this technique.

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2. Phillips, R. W., and Ito, B. Y.: Factors Influencing the Accuracy of Reversible Hydrocolloid Impressions, J.A.D.A. **43**:1-17, 1951.

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TECHNIQUE FOR MASTER IMPRESSIONS IN FIXED RESTORATIONS

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AN ACCURATE SET of full-mouth working casts are a necessary part in the construction of fixed restorations. These casts, when articulated, should have the respective dies of the prepared teeth in their correct positions in the arches. Thus, in making the original castings, as much emphasis can be placed on the size and shape and occlusion of the castings, as is placed on the gingival fit. This is extremely important from a periodontal standpoint, since all fixed restorations should function in the mouth as an integral part of the masticatory apparatus.

To obtain such working casts, the materials used are: (1) wax, (2) plaster, (3) alginate, and (4) modeling compound.

1. The wax "squash bite" usually results in jacket or veneer crowns which are built too high, as well as too far toward either the buccal or the lingual side of the arch. Thus, a restoration which looks perfect on the cast usually has to be changed when it is introduced into the mouth. This is due to the distortion of the wax while it is being removed from the mouth, or when the die is introduced into the wax, or by changes caused by the heat developed during the setting of the stone. Also, it is very difficult to make sure that the patient is registering his centric relation accurately while he is biting into a large piece of wax.

2. Plaster will give a good end result, but its use in full impression is hard on the operator as well as on the patient. This is due to the following: (a) The many undercuts existing where the teeth are present necessitate the removal of the impression in sections. (b) Special skill is needed to obtain a complete impression of the arch. (c) The bulk of plaster necessary for a full impression produces heat, and the changes which occur while the plaster is setting are not pleasant to the patient. Therefore, while it would be easy to use plaster for a small segment of the arch, it becomes much more difficult when plaster is used in obtaining full impressions.

3. The alginates can be used to reproduce the dental arches very accurately, but it is very difficult to seat the dies in their respective positions and to keep them in place while the casts are poured.

4. A modeling compound impression may be distorted upon removal from the mouth, producing an inaccurate cast.

A combination of plaster and alginate in a one-piece over-all impression will reproduce the contours of the mouth both accurately and quickly. The plaster is

Received for publication March 19, 1955.

used in those areas where teeth have been prepared (in order to hold the dies), and an alignate is used to reproduce the rest of the dental arch. The resulting cast will make it easier to develop the correct occlusion and the alignment of the structures which are so important in the construction of functionally correct abutments and fixed restorations.

Fig. 1.

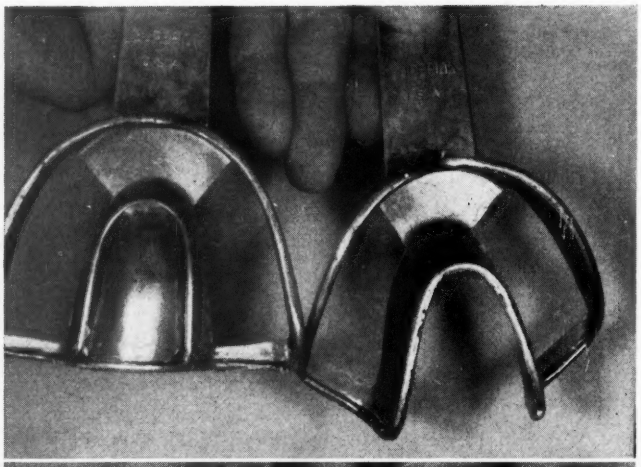

Fig. 2.

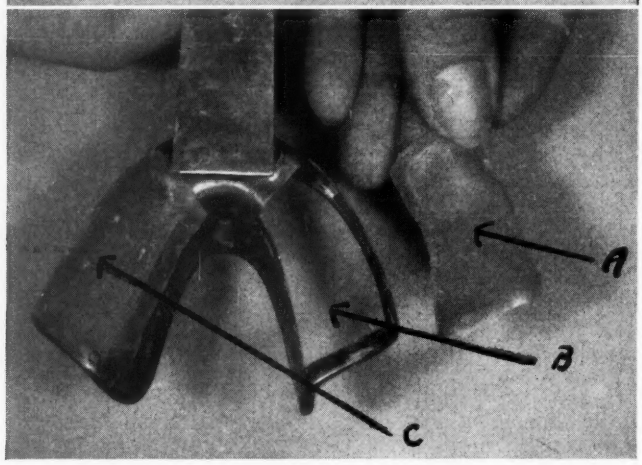

Fig. 1.—Upper and lower trays prepared for combination alginate plaster impressions.
Fig. 2.—A cutout tray with wax covers. *A*, A wax cover to be luted in position. *B*, The prepared hole in the tray which the wax piece will cover. *C*, A wax piece luted over the cutout area.

COMBINATION IMPRESSIONS

Use a modified tray for alginates which covers the entire jaw. Prepare the modified trays by cutting out part of the occlusal portions of the regular alginate trays. The cutout section includes the region distal to the canine tooth posteriorly, to the end of the tray, except a small strip of metal left at the distal end of the tray to

hold it together. The trays with these cutout areas are used for posterior restorations (Fig. 1). For anterior restorations, only the occlusal portion of the anterior segment (from canine to canine) is removed.

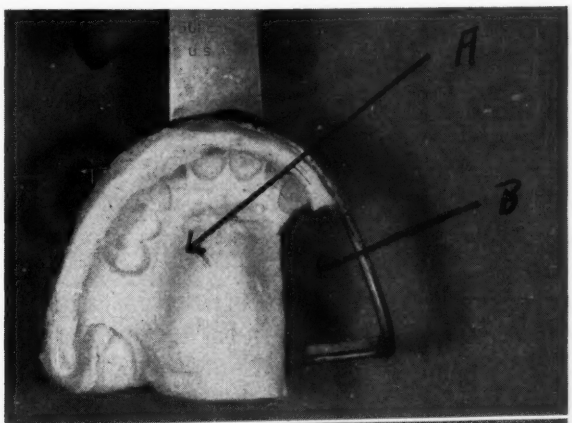

Fig. 3.

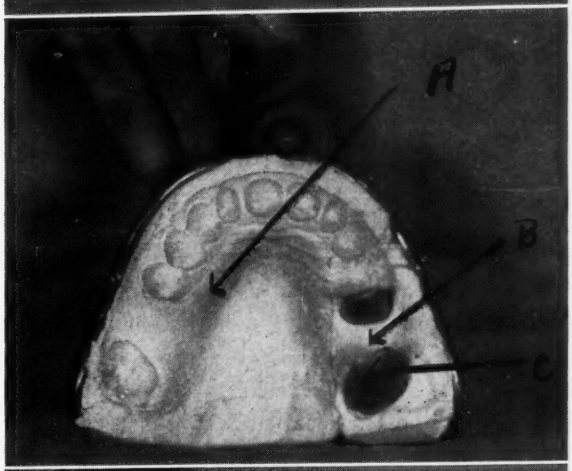

Fig. 4.

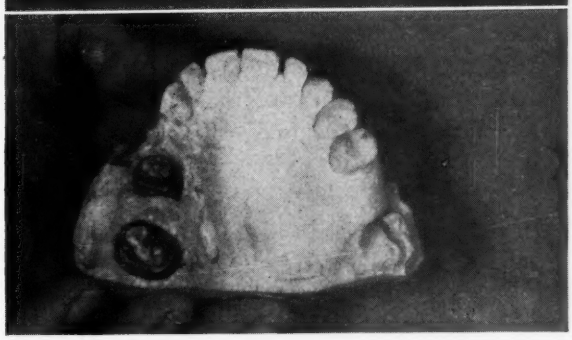

Fig. 5.

Fig. 3.—A cutout alginate impression. *A*, The retained and undisturbed portion. *B*, The alginate has been removed from the region where restorations are being made, and prepared for the introduction of plaster.

Fig. 4.—The completed combination impression ready for pouring. *A*, The alginate part of the impression. *B*, The plaster part of the impression. *C*, The dies are in position in the copings which are held in plaster.

Fig. 5.—The completed cast with the dies in place.

Cover the cutout parts of the tray with a layer of red wax, and lute it in place on the tray. Removable metal coverings may be used for this purpose but are not necessary (Fig. 2).

Fill the tray with a mix of alginate impression material and make an over-all impression of the entire jaw. Try to obtain an impression of as much of the mouth as possible, including the reflected border tissues. This is necessary so that the alginate impression will snap back into place when it is reintroduced into the mouth later.

Remove the alginate impression from the mouth and cut away part of the alginate impression material in the region where restorations are being made, and remove the red wax which is over this section. Save the piece of red wax for use later. To make provision for the plaster, cut the alginate from the mesial side of the anterior abutment to the distal of the posterior abutment. Cut away enough alginate lingually to provide space for the necessary thickness of plaster to hold the copings in place. Remove all of the alginate from the buccal side in this region. This is done so that the plaster will extend to the flange of the tray and be held in position by the undercut in the tray itself. For a lower impression, all of the alginate is removed from the lingual side of the teeth so that the plaster will be held by both the buccal and lingual sides of the tray (Fig. 3).

Place the transfer copings on the prepared teeth. This step is not absolutely necessary, but it is much easier to seat the dies into the copings rather than directly into the plaster.

Replace the prepared alginate impression back in the mouth. It will snap into its correct position if there is a complete impression of the tissues up to the reflected border tissues. Be sure that enough alginate has been cleared away so the region where the restorations are being made is entirely free and open for the introduction of the plaster.

Make a thin mix of quick-setting plaster. With a small spatula, place the plaster through the hole in the occlusal surface of the tray so it surrounds the copings and covers the edentulous areas of the ridge. Place an excess of plaster in the opening in the tray and condense it by pressing the piece of red wax (removed before the alginate was cut out) into place over the opening in the tray.

Allow the plaster to set for four minutes, and then remove the impression from the mouth. The impression will be removed easily in one piece with the transfer copings in place in the plaster part of the impression (Fig. 4).

Place the dies in their copings and pour up the cast. Also, pour up a full alginate impression of the opposing jaw (Figs. 4 and 5).

When these casts are occluded, the result will be a set of full-mouth impressions with each die in its correct position, and few, if any, changes will be necessary when the finished product is inserted in the mouth. This technique attains a better end-result with a minimum of effort, and saves chair-time now lost in grinding-in so-called finished restorations.

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COMBINATION IMPRESSION FOR FIXED RESTORATIONS

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IN THE EVERYDAY practice of dentistry, countless fixed restorations of two, three, or four units are constructed. Many of these restorations are built to an existing occlusion which may or may not have been corrected prior to their construction; that is to say that unilateral bridges are constantly being placed in mouths where no extensive occlusal change is required.

As in any phase of restorative dentistry, the placement of the restoration in harmony with the existing occlusion is a delicate task. For the unilateral restoration, this task is made more difficult by the fact that it is not always a simple procedure to obtain a full mouth impression in order to construct the working cast for the assembly of the restoration.

For reasons of expediency, the final impression is usually made in a small unilateral tray. The working cast obtained in this manner covers an area only of the abutment teeth, and perhaps one or two teeth beyond them on either end. These casts are most commonly mounted on small, flimsy articulators, and even though the centric relation registration may have been accurate, the establishment of correct occlusal contacts is a haphazard procedure because of the mobility and play in the small articulator, and because the entire dental arch is not available on the cast.

There should be little argument that a working cast of the entire dental arch which is mounted on a solidly built articulator will facilitate the building of a more accurate restoration. A hydrocolloid technique, of course, permits such a cast to be made from a full impression with ease, but this technique is not in universal use. By any other method, the impression of the full arch is more difficult. Whether primary castings to cover the abutment teeth have been made, or whether transfer copings are being used, most dentists will not make a full plaster impression of the arch because of the difficulty involved in securing it.

Techniques in which plaster indexes are made over the abutment and edentulous areas, followed by an alginate impression made after the plaster has set, have the disadvantage that the entire block of plaster may be displaced, since it is surrounded completely by alginate.

THE COMBINATION IMPRESSION

The combination impression method will permit a relatively simple full-arch impression to be made by using plaster of Paris and alginate impression materials

Received for publication Feb. 16, 1955.

in the same tray at the same time. For purposes of description, let us assume that we are constructing a four-unit fixed restoration with full cast veneers on the lower left first bicuspid and second molar, and that the second bicuspid and first molar are missing. The abutment teeth have been prepared, dies have been made, and transfer copings have been made accurately on these dies. The copings are placed in position on the prepared teeth. A rim lock tray (not water-cooled) which fits comfortably in the mouth is selected. The center of the tray is placed at the midline of the arch, and the external surface of the tray is marked with a pencil at the position of the most anterior abutment tooth. The tray is removed and set aside to receive the impression material.

Fig. 1.

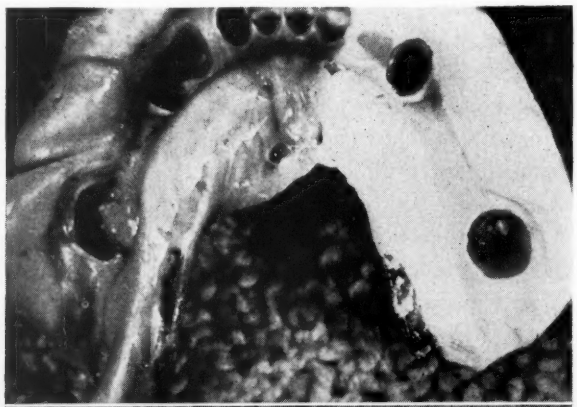

Fig. 2

Fig. 1.—A lower alginate and plaster impression. The left bicuspid and molar transfer copings are locked in plaster.

Fig. 2.—An upper alginate and plaster impression. The left lateral and cuspid, and right cuspid and first bicuspid transfer copings are locked in plaster.

Two persons are required for the preparation of the impression materials. The alginate impression material is mixed by the dentist and plaster of Paris is mixed by the assistant, both mixes being completed at the same time. The plaster is placed carefully in the edentulous and abutment areas in the tray and allowed to extend slightly beyond the abutment position as indicated by the pencil mark. The alginate material is then placed in the remainder of the tray and brought into direct contact with the plaster. The completely filled tray

is then placed in position in the mouth, and both materials are allowed to set at the same time.

When both the plaster and alginate are completely set, the entire tray is removed. The ease with which this can be done is usually surprising. The plaster and the alginate will have flowed together smoothly. Usually the transfer copings will be embedded in the plaster, and the plaster will be locked solidly in the tray (Fig. 1). The dies can be seated with the assurance of complete stability, and a full working cast is made easily.

This method is simple and practical, but it may require a few impressions being made before the dentist gets the "feel" of handling the plaster and alginate materials simultaneously. Occasionally, because of improper tray positioning, a coping or casting will be embedded in alginate rather than plaster, but experience will soon eliminate this difficulty. If there is a heavy buccal or lingual undercut in the edentulous or abutment area of the alveolar process, it is best not to use this method. Since the plaster will not be separated before its removal from the mouth, the soft tissue in the undercut can be bruised when the impression is removed.

The judgment of the dentist will determine the situations in which this technique is applicable. It can be used in many situations other than the one described. It may be used for a single veneer or jacket crown in the anterior region, as well as for a large anterior bridge. For these situations, the plaster is placed in the anterior section of the tray, and the alginate material is placed bilaterally in both posterior sections (Fig. 2). For posterior bridges on both sides, the plaster is placed in both posterior sections, and the alginate material is placed in the anterior section. Other conditions suggest various other combinations of plaster and alginate materials in the same tray.

SUMMARY

An impression procedure for fixed restorations which provides an accurate registration of the relation of the abutments and the edentulous areas, and yet provides a full working cast, has been described. A few of the many situations to which it can be adapted have been described. Experience in its use will suggest other situations in which it can be applied.

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THE PROBLEM OF FUNCTION IN RESTORATIVE DENTISTRY

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FUNCTION IS THE PRIME object of restorative dentistry. The proper care and treatment of the oral organ should be the concern of all practitioners of dentistry, and of necessity this requires a knowledge of the form and function of this organ—its parts, how it can be, at least figuratively, taken apart and put back together,[1] how it is made, and how it works in health and disease. In other words, a complete knowledge and understanding of the anatomy and physiology of this most important organ is a "must."

We render "lip service" to what has just been said, but I seriously question whether the majority of us apply the knowledge available in making an oral diagnosis, and then use the revealed facts in the treatment of dental ills. The author must admit, that in spite of an excellent and rigid training in the basic sciences, his failure to apply this knowledge properly has led to many failures. These disappointments were not one bit lightened by observing that many of his colleagues were having the same bad results. We were failing "to restore the teeth to better function, so that they will chew well, work harmoniously with each other, and thereby promote the health of the gums and their substructures."[1] We did not have a philosophy of dental practice, and it became necessary to stop and ponder what Granger[2] so aptly said: "Dentistry in general stands today acutely in need of a practical rational philosophy, based upon a biologic concept of the human mouth; a bio-mechanical basis for dental practice."

The importance of a healthy and functioning mouth will not be questioned, but the "how" of attaining this goal is something that may cause many a heated argument, because ideals and ideas are many and varied. What one may consider successful and the ultimate may not look quite that way to someone else. If we are willing to subject the facts to careful scientific scrutiny and practical application, and not start injecting or questioning one's opinions, then we will have a basis for reaching conclusions by the light of reason and not emotions. An honest evaluation of the facts divorced from certain fears, prejudices, mental laziness, authoritarian figures, or even the overpowering urge to prove something, is a sound premise upon which to "face up" with an important problem. This is the only method that should be used by members of a learned profession.

Read before the American Academy of Crown and Bridge Prosthodontics in Chicago, Ill., Feb. 5, 1955.

Received for publication March 8, 1955.

PHYSIOLOGIC TOLERANCE

Let us go back two decades, and those who were interested in this problem of function surely must remember the great impact the spherical theory of occlusion made upon the dental profession. Some of the drawings and mathematical calculations were very impressive to the uninitiated, but the thought that there was not any scientific analysis of jaw motions to support the assumptions of this theory never dawned upon many of us. In other words, we blindly followed a technique, step by step, without a scientific evaluation of the facts—probably on faith, authoritarian faith.

The results were unsatisfactory and even disastrous in some cases, but in spite of the fact that a reappraisal of the situation was necessary, the baffling question was why some restorations functioned without any serious consequences, but failed, in the main, to accomplish the desired results. (This was also true of several other techniques that were advocated and used.) It became obvious, after a while, that in all probability the functional demands of the patients were not in excess of the metabolic level. Had we understood what is theoretically perfect function, and then made our compromise approach that as closely as possible within the physical limitations imposed upon us, nature's metabolic processes, in all probability, would have provided the necessary tolerance to have made many of our restorations successes instead of failures.

The next important observation was that in spite of the correct anatomic form given the restorations it became necessary, in most cases, to modify them extensively, and sometimes even to the extent of obtaining flat occlusal surfaces. This certainly showed that teeth could not be articulated upon a spherical basis with the idea that the mandible could be made to adapt its condyles, and its centric position to a prescribed tooth relation.[8]

An experience that was shared with a colleague seemed to point toward the fact that restorations with cusps on the teeth are desirable. My colleague lost two posterior teeth, and an examination of the remaining teeth showed beautifully formed teeth that were in good occlusion. (I have since learned that no dentist can determine the condition of the mouth by just looking at it in centric closure, or as the mandible makes its excursions.) He had fallen in line with the "cuspless teeth" school of thought, and asked that his bridge be constructed along these lines. It was finally decided that two bridges be constructed—one following his specifications to be cemented temporarily and worn for a period of three months, and one to be constructed using the correct anatomic tooth forms (with cusps) to be worn for a similar period of time. At the end of the experiment he accepted the second bridge (with cusps), because, as he said, he could chew his food much better, and it required less force to accomplish this act. Since that time many other patients have said the same thing, which proved that "when the teeth are well articulated and sharply ridged, few strokes of the mandible are necessary to shred a bite of food, but when dulled many more and heavier strokes are necessary. Bone does not build upward against continuous force."[8]

"Well articulated" is what rang a bell, but how should we go about performing this act? Certainly not by using the mouth as an articulator, because the mouth

is not a good articulating instrument. Certainly not by the use of articulators that require guessing or averages for their adjustment, because we must obtain certain definite records from the head to work with so as to know what the proper correction should be. Certainly not by falling in line with those who, because of a reluctance to gather and apply the facts known to oral physiologists, feel that individuals of middle age or older should have greatly modified cuspal form or even cuspless teeth.

These conclusions showed that a thorough review and study of oral anatomy, oral physiology, and pathology was in order, and as McCollum[3] has said: "Oral physiology must be understood before masticatory pathology can be comprehended, and the articulation of the teeth becomes the fundamental factor in an understanding of this subject." We must not be content to observe the forms of the teeth and try to imitate their likenesses without understanding their anatomy and purpose. We must understand the actions of the joints, and the muscles that operate the mandible.[1] We must understand that the temporomandibular joint is not a loose sloppy mechanism which will conform to any given set of tooth forms and arrangement, because it can be demonstrated that repeated tracings of the same path may be superimposed, one over the other, and they will be identical in character.[5]

The problem seemed to resolve itself into a very important fact, which is that the practice of dentistry is the science of occluding teeth. Reaching that conclusion made it necessary to comprehend the fixed biologic factors, and also those subject to change by the dentist, that are involved in the occlusion of the teeth. The cusps, sulci, and fossae of the teeth that will function properly in any given mouth are the result of these fixed and variable factors.[5] It is our job to record them and to make our restorations according to them, if the restorations are to be successful.

BIOLOGIC FACTORS

An attempt will be made to describe the biologic factors which must be understood in order to create and maintain a physiologic articulation; this knowledge will show the importance of using teeth with cusps, and the ways and means of making them function properly.

A great debt of gratitude is due the members of the Gnathological Society, and especially its guiding spirit, Dr. B. B. McCollum, for the outstanding research work conducted over a long period of years at a great personal sacrifice. The men of this group not only gave us the basic knowledge of mandibular movements and physiologic occlusion of the teeth, but they developed the instruments with which it is possible to record and duplicate actual dynamic jaw relations.[5] A study of the "Research Report" by McCollum and Stuart[6] will repay one many times because of the valuable material contained within the pages of this report.

From a purely functional standpoint, each temporomandibular joint consists of two joints: the joint between the condyle and the meniscus, and the joint between the meniscus and the glenoid fossa. The hinge action occurs in the lower compartment of the temporomandibular joint, and the condyle path movement occurs in the upper compartment. The hingelike movement of the mandible is

accomplished by a simple rotation of the condyles on the lower surfaces of the menisci, and this movement may take place at any point along the condyle path.

THE HINGE AXIS

The hinge axis can be located accurately by trial and error by means of a hinge-axis bow which is rigidly attached to the lower teeth by an aluminum clutch, or clamped to the edentulous ridge. The side arms of the bow are adjustable horizontally and vertically, and carry pointed styluses which are directed at the positions of the condyles. The patient is coached to open and close the mouth with a pure hinge movement. Each stylus is adjusted until a point is located on the face where the point of the stylus remains stationary as the mouth is opened and closed. This is carried out on both sides simultaneously, and the points so located are transferred to the skin. By locating the center of rotation for each condyle and joining these with an imaginary line, the hinge axis is located. These points in the axis of rotation are now related to a third point on the side of the nose. This point is usually placed on the right side of the nose ¼ to ½ inch below the level of the inferior border of the orbit. These three points are on the axis-orbital plane which is a plane of reference. They are used to make a conventional face-bow transfer so that the casts will be oriented on the articulator in the same relation to its axis as the jaws are to the hinge axis. The axis is constant to the mandible, and it determines the arc of closure upon which the cusps of the teeth meet in any contacting position. For convenience, the hinge axis is located and reproduced in centric relation.

The question is often asked—"What is the importance of locating the hinge axis?" The answer is that it proves the basis of all transfers, and makes the study and treatment of masticatory pathosis infinitely easier and more intelligible. If the casts of the mouth are not mounted on the hinge axis, the mounting is worthless because (1) restorations constructed on it cannot meet correctly in the mouth in any position other than the static position in which the maxillomandibular relation record was made, (2) a centric relation record cannot be checked, (3) an articulator cannot be adjusted to reproduce jaw movements accurately, (4) an occlusion that has cusps meshing in the same arc of closure as the mandible cannot be fashioned, and (5) changes in vertical dimension on the articulator, if necessary, will produce inaccuracies in the occlusion.[7] Most of the troubles encountered with our restorations are traceable to the failure to maintain the proper relation to the hinge axis.

CENTRIC RELATION

Granger[8] has said that regardless of our beliefs with respect to cusps, articulators, materials, or methods, there is no single factor in all dentistry equal in importance to centric relation. For all practical purposes, centric relation is the most retruded position into which the muscles of mastication can pull the mandible. It is the terminal hinge position of the mandible, the one in which the hinge axis is constant to both the mandible and maxillae. It must be kept in mind that

the only position at which it is possible to locate and reproduce the hinge axis is at centric relation, and that centric relation is only one position of the hinge axis. Therefore, if the hinge axis is located and reproduced with the condyles in their most retruded positions, and if it is reproduced in the restoration, the restoration will meet in correct rotational relationships in every position of the mandible, since the hinge axis is constant to the meniscus in every mandibular position. The usual definition of centric relation as the most retruded position of the mandible from which lateral movements can be made is inadequate because it fails to consider the relationship to the hinge axis. The hinge axis is the main reason centric relation is important. The Bennett movement, which is the power movement of the mandible, takes place with the condyle braced against the fossa, and it is another reason why centric relation is of fundamental importance.

A study of the chewing cycle will show that restorations constructed with the jaws out of centric relation will transmit forces as lateral pressure against the bone supporting these malrelated cusps, instead of a vertical thrust as in a normal relationship. These lateral forces cause destruction of the supporting bone. Also, as Granger[8] said, "If the vertical dimension of occlusion is increased materially, centric relation is an absolute prerequisite to muscle length and physiologic rest position. Without centric relation there can be no physiologic rest position." If the centric relation record is incorrect, all other records will be worthless.

THE CONDYLE PATH

The condyle path has an inclination and a curvature, and this inclination and curvature has a definite effect on the requirements of occlusion. It is important to note that the condyle path exerts its greatest effect on the balancing cusps because the condyle travels down the condyle path on the same side that the balancing cusps move over each other. Neither the condyle paths nor the opening and closing axis of the jaws can be seen, but by geometric and instrumental means their character and inclination (two vitally important interrelated factors of occlusion) can be determined.

There is a wide variation in the paths taken by the condyles. (Most of them are curves.) It is important to know the character of the condyle path and reproduce it precisely, because this is one of the fixed factors of occlusion that cannot be changed. A method has been evolved for determining from the patient the precise character and shape of the condyle paths and how they slant.

THE BENNETT MOVEMENT

Mastication is carried out almost wholly with the Bennett movement. It is the jaw movement that the patient uses to triturate food. It is the power movement, and some think it is the most important of the masticatory synergy.

Lucia[7] has pointed out that the glenoid fossa, in addition to having an anterior curvature and inclination, also has a medial curvature and inclination. The Bennett movement is the combination of rotation and gliding medially of the condyle on the working side, and it dictates the positions of the working cusps. Because it is a side-to-side shearing action, the cusps must be fashioned in such a way that they

will permit the movement of the cusps through the corresponding sulci. If the cusps are not in harmony with the Bennett movement, the forces of mastication become traumatic lateral forces which are very destructive to the supporting tissues. The Bennett movement may be in a straight line, but it generally is along a curved line.

Individuals have Bennett paths that are purely personal to them, and these paths on the two sides of the individual may also be, and generally are, different. In fact, there may be no Bennett movement in some patients. This variation can be explained as follows: In many patients, the so-called centers around which the lateral movements of the jaw rotates lie back of the hinge axis. When they do, there is a definite side shift of the condyles in the lateral movements of the mandible. This is known as the Bennett movement. If the centers of the lateral movements lie in the hinge axis, there is no side shift in the lateral movements of the condyle. In such patients there is no Bennett movement.

Unless all of the fixed biologic factors are faithfully recorded and reproduced, and unless the variable factors that are not anatomically fixed, such as the plane of occlusion, compensating occlusal curve, anterior guidance, and cusp height, are wisely altered by knowing how they are related to the fixed factors, many failures would occur in restorative work. In other words, these factors must be understood in order to create and maintain a physiologic occlusion because, under any given fixed set of these factors, there is only one set of cusps that can function in harmony with jaw movement.[5]

RECORDING AND TRANSFERRING THE FIXED BIOLOGIC FACTORS

The next problem is a means for recording and transferring these fixed biologic factors accurately. I have floundered from one school of thought to another, from one technique to another, unable to find the answer to the problem until I became interested in gnathology.

After a serious study of oral physiology, anatomy, pathology, etc., I felt I was in a position to gather, evaluate, and apply the facts in such a way as to determine if the mouth could really function physiologically by following the principles of gnathology. The results were most gratifying. By means of the hinge-bow and the gnathograph, I am able to record accurately the opening and closing axis, the protrusive, the protrusive lateral and the basic lateral positions, with or without the Bennett movement, as the joints dictate. In the gnathoscope, I have an articulator that can reproduce, not only the relative positions of the mandible to the maxillae, but all paths of motion to a definite and precise degree. And also, because of the accuracy of the method of transfer, it is possible to make remount casts of the restorations, and examine the occlusion on the articulator. This is very important, and it can be done any number of times.

Gnathologists tell us that whenever the teeth are placed in proper occlusion, their periodontium improves in health and tends to remain healthy. A knowledge of the laws of occlusion is very important, and Thielemann's[9] formula,

$$\frac{CO \times I}{OP \times OC \times C} = \text{Equilibrium of articulation,}$$

can be of value to indicate the compensatory changes required. A thorough knowledge of the way the mouth functions is necessary. When we obtain this knowledge, the results of our efforts will be most gratifying.

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PERIODONTAL ASPECTS OF FIXED BRIDGE FAILURE

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AN AUTHORITATIVE textbook on fixed partial prosthesis[1] lists as the objectives of mouth reconstruction: (1) correction of abnormal oral conditions; (2) restoration of all masticating organs and related parts; (3) maintenance of these organs in a normal healthy condition for as long a time as possible; and (4) prevention of further injury.

If these be the criteria by which fixed bridges are made, it becomes immediately obvious to the honest observer that too many restorations are failures. And yet the complacency in this regard is impeding the advancement of fixed prosthesis.

Anyone familiar with War Department medical form No. 57, which is a monthly compilation of dental treatments, has probably viewed with mixed emotions, the column headed "Recementation of Bridges." To me the conclusion is painfully obvious. The Army *is* realistic, and believes that some bridges will not stay cemented to their abutments. This fact is based on statistical evidence.

It is with calculated presumption that this Academy is addressed on the subject of failure of fixed restorations. The members of such a group hardly need be told that fixed bridges fail. Almost all articles, clinics, and postgraduate courses in fixed partial prosthesis are devoted to the technical aspects of bridge construction and geared to the consequent reduction or elimination of failures. These include treatises on preparation, impression making, where and how to finish margins, protection of cusps, how to prevent breakage of solder joints, and myriad other details which are all mechanical.

To many observers, however, it seems that by the same token as we know enough and have the technical ability to save a tooth attacked by caries, so, too, do we have at hand the technical knowledge to keep a bridge cemented to its abutments. We have at hand, also, the ability to prevent the fracture of a pontic, or a margin failure. If these were the only reasons for bridge failures, they *can* be, and *are being,* overcome. Because actually only carelessness or lack of desire to use the resources at the disposal of all dentists (or perhaps, rarely, factors completely beyond our control) contribute to failure from these causes.

But bridges fail too, as we all know, when they are technically well fabricated. They fail because the foundation fails, or has the potentiality of failure even before construction of the restoration.

Read before the American Academy of Crown and Bridge Prosthodontics in Chicago, Ill., Feb. 6, 1955.

Received for publication March 8, 1955.

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There is a much-abused canard to the effect that for every tooth lost from caries, four are sacrificed to periodontoclasia. Persons who have had the benefit of adequate dental care from childhood could conceivably lose ten teeth to periodontal disease, for every one lost to caries. From this we must deduce that filling teeth does not *cause* periodontal disease, but merely saves them until such time as the slow insidious ravages of such disease become apparent.

It then seems to follow, in construction of fixed restorations, that the real problem in eliminating failures is the preservation of the bone support of the teeth. For if we have available all the technique and knowledge for mechanical perfection, careful application and meticulous attention to detail are all the requirements necessary to a successful result. In this manner mechanical failure should be completely obviated.

But—what about failures that are biomechanical or periodontal? These seem to be more nebulous, more likely to be ignored, and certainly not based on such concrete fundamentals, for instance, as controlled expansion of a casting mold. These failures, however, can and must be eliminated by correct judgment in diagnosis, correct operative technique from the periodontist's viewpoint, and adequate patient education.

DIAGNOSIS

If any of these three can be assumed to have priority in importance over any of the others, certainly diagnosis should be placed first. Thinking through the problem, envisioning the final product, and anticipating factors that cause bridges to fail must come first.

The influence that periodontal considerations should have on the diagnosis and treatment plan for fixed partial restorations becomes apparent when one reflects that the very need for a restoration implies that tissues or teeth have been lost. Hence those teeth that remain must carry an increased load. Depleted in number and quality, they must now support the entire force of the masticatory process. The plight of these remaining teeth may even be considerably worsened, for the periodontal destruction which so often accompanies or precedes the loss of some teeth may also weaken the periodontal attachments of those that remain.

The same principles that hold true in the treatment of periodontal disease must be at hand when we, as rebuilders, plan our restorations. In other words, exactly what the periodontist would consider in treatment, we must consider in prevention. And in order to prevent tissue loss and subsequent failure of our restorations, we must be able to apply this information clinically.

The interpretation of radiographs in our treatment planning is the single greatest tool for the prevention of subsequent bridge failure. This is a must; the fundamental; the sine qua non of the pretreatment planning. The "bone factor" does not preclude the observation of various clinical phases of periodontoclasia, such as mobility, pocket formation, presence or absence of pus, migration, etc., which are also important. But the effect of all these on the underlying alveolar bone is *why* they *are* important. The "bone factor" has to do with alveolar bone loss.

There are numerous local factors destructive of tissue: for example, chemical or bacterial agents, thermal changes, or mechanical or functional forces can initiate inflammation and its sequelae. The extent of destruction or inflammation is completely dependent on the individual "bone factor" which is itself a composite of all systemic and local influences. Thus, no local destructive influences might be present at all, and still bone destruction may be evident. Conversely, many destructive influences may be present without the usual sequelae.

The diagnosis and treatment plan, as well as the prognosis of our reconstruction depend on whether or not the individual "bone factor" is favorable. But *how* can we determine whether or not there *is* a favorable "bone factor?" It becomes necessary to correlate clinical, radiographic, and study cast evidence. It is then judged in terms of severity and duration of the total local destructive influences.

The appraisal of the "bone factor" is expressed as follows, according to Glickman:[2]

"1. *Positive Bone Factor.*—Favorable response—slight to moderate bone loss and slow destruction in the presence of marked local disturbances over a long period of time.

"2. *Negative Bone Factor.*—Unfavorable response—marked rapid bone loss in the presence of slight local alterations.

"3. *Negative Bone Factor.*—Unfavorable response—appreciable bone loss in absence of any other notable local periodontal disturbance."

Obviously then, from these formulae, the periodontal prognosis can be estimated with some degree of accuracy.

By taking advantage of the judgment based on the "bone factor" we will not be doing the patient more harm than good (or overtreating). We will not preserve teeth with superior skill, that would have been lost with less skillful technique, just for the sake of constructing a restoration. By not observing what can be learned from the "bone factor" evaluation, we would be merely preserving comfortably diseased teeth which become a slow insidious menace to health. This ultimately results in failure of the restoration anyway.

PROGNOSIS

Over-all prognosis is then judged by the positive or negative nature of the "bone factor." The prognosis of individual teeth is determined after this general prognosis is established.

The amount of bone remaining in relation to the teeth is important in determining this general prognosis. However, the rapidity of the destructive or inflammatory changes, the nature of the bone response, and the status of the individual "bone factor" are actually the significant guides to the ultimate success or failure of the restoration. All periodontal tissue loss can be related to the "bone factor," and, as all people have different "bone factors," bone *levels* that are comparable are in no way prognostic of the success or failure of a bridge.

In this regard, clinical practice which attempts to determine prognosis on the basis of whether one-half or one-third of the bone remains, without study of the

whole patient and correlation of oral findings with radiographs and study casts, is inconsistent with the fundamental nature of periodontal pathosis and can in no way be helpful in judgment as to future success or failure of a restoration.

OCCLUSAL TRAUMA

Of all the disturbing influences that cause bone or soft tissue loss around abutment teeth, there is no question but that occlusal trauma is culpable in the failure of too many restorations. In 1935, Schuyler[3] stated, "Authorities in all branches of dentistry are united in the recognition of abnormal or excessive occlusal stress as a *primary* cause of disease and destruction of the tooth-supporting tissues."

The dentition is exposed to continuous changes in function and structure. These changes include physiologic mesial migration of teeth, and occlusal eruption of teeth. They are physiologic processes which go hand in hand with the continuous apposition of cementum and regeneration of fibers attaching the tooth to the alveolar bone. These processes take place most favorably if the functional relation between the teeth is optimum. Malocclusion, occlusal disharmony, cuspal interference, premature contacts, or any unphysiologic tooth replacement will disturb the functional relation of the teeth.

When supporting tissues of the dentition are diseased, or when natural functional adaption of tissues is impaired, it is of paramount importance to have this optimum functional relation, preventing and eliminating damage inflicted by occlusal disharmonies. It must also be realized that, despite good occlusal relationship, masticatory forces might be traumatic. For this reason, splinting, or use of multiple abutments is very often the only means of prevention of failure of a restoration.

BIOLOGIC FACTORS

The question of occlusal trauma and its prevention, however, is not an exclusive problem of mechanics. It is also a biologic problem, and an understanding of the biomechanics is essential.

The two main biologic factors that affect our work must be recognized. They are:

1. Periodontal diseases are disturbances of the supporting tissues. Functional disharmonies constitute a serious aggravating factor under such conditions.

2. The supporting tissues of the teeth are built according to functional requirements. The better the functional relationship between mandibular and maxillary teeth in all positions, the less strain on the supporting tissues. This assures most favorable tissue response to functional demands.

Obviously, then, the connecting link between health of supporting tissue and mechanical procedures of dentistry is optimum function. And the sole aim of dentistry for each individual case should be to seek that optimum function.

Function is thought of in terms of occlusal equilibration. Orban,[4] who is a researcher in the field of periodontics, has put it this way:

"These are the objects of occlusal equilibration:

"1. Balance the occlusion and articulation to harmonize with musculature and temporomandibular joint.

"2. Bring occlusal forces into direction of long axes of teeth by bringing lingual cusps of maxillary teeth into central grooves of mandibular teeth, and buccal cusps of mandibular teeth into central fossae of maxillary teeth.

"3. Distribute forces in eccentric position to greatest possible number of teeth. *Eliminate* balancing side contact.

"4. Establish static relation between cusps and opposing fossae.

"5. Reduce steepness of cusp inclines and establish similar inclines on all teeth.

"6. Reduce size of occlusal contacting surfaces.

"7. Retain sharpness of cusps and establish smooth gliding planes.

"8. Do not interfere with rest position of the mandible."

If the foregoing are desirable, and I think they are, then the prevention of periodontal disease per se, as well as the prevention of periodontal disease as a concomitant or resultant of fixed bridge prosthesis, must be the aim of every attempt at restoration of the mouth, whether it be a simple filling, a small bridge, or complete occlusal rehabilitation.

Periodontal disease is a functional disease. Function can be classified as underfunction or overfunction, both being deleterious to supporting structures.

Excessive stress promulgated through too-steep cuspal inclines, or too-prominent cusps can make traumatogenic a seemingly innocuous pressure. Restorations which are not in harmony with the general form of occlusion, or which create more pressure on some teeth than on others in various excursions of the mandible, will cause periodontal inflammation. The presence of good occlusion in centric position is not a sufficient safeguard for the preservation of the teeth in a healthy environment. In 1939, Maxwell[5] stated: "The equitable distribution and reduction of torque to a minimum are an imperative necessity to any restorative procedure of a comprehensive scope, where the welfare of the peridental membrane is a concern."

It is well known that the periodontal membrane and supporting bony structures of the teeth can withstand great occlusal stress in a vertical direction. As a matter of fact, any attempt to extract a tooth without luxation or rotation encounters tremendous difficulty. Conversely, in trying to preserve the integrity of the supporting structures, the occlusal forces should be directed vertically. In a normal mouth, the stress is never completely vertical because the forces are applied to inclined planes. Those forces are transmitted in a more or less lateral direction, depending on the steepness of the inclines and on the length of those inclines. Vertical force results from flat occlusal surfaces, but that also reduces masticatory efficiency through the loss of shearing action and can cause trauma because of excessive depressing forces. The greatest lateral pressures result from occlusal forces on teeth with long steep cusps. Shorter and shallower inclines cause less lateral pressure. The supporting structures are best able to withstand pressures in a nearly vertical direction. Hence, in design of the occlusal surface, as much lateral occlusal stress as possible must be eliminated, yet shearing action on the food bolus must be maintained. The distance between the bucal and lingual cusps must be restored to not more than two-thirds of the original greatest buccolingual width, and cusp inclines should be kept at a 20 degree angle or less, and in harmony with the rest of the dentition. It may be necessary to accomplish this by adjusting the other natural cuspal inclines, and, if so, this is surely indicated.

TEETH OUT OF FUNCTION

Another facet of the functional aspect has to do with teeth being out of function for considerable periods of time. When these are restored to masticatory activity through the placement of bridges, it may take several months before the effectiveness of the alveolar process is sufficiently restored by bone reorganization, so that the patient can use, comfortably, an otherwise efficient restoration. Sometimes it may even be advisable to construct temporary bridges or temporary splints for patients that fall into this category.

MUSCULATURE

Masticatory musculature which is very powerful should be considered with caution as a risk in restoration, if there is a concomitant weakness of periodontal support. An imbalance between pressures applied and the ability to withstand them will cause the failure of a restoration. Muscular abilities vary greatly and, if necessary, can be studied with the aid of a gnathodynamometer. However, the use of considered judgment in these patients with large muscles is usually sufficient.

This leads naturally to a very moot question. Should the maxillomandibular distance be increased? Should the vertical dimension of occlusion be increased? These cases are to be considered very carefully in the light of crown-root ratio. In other words, will the amount of resultant clinical crown exceed the support we can expect from the length of bone-supported root, if the clinical crown is lengthened? Of course, heavy musculature and small conical roots that are not well embedded are hazardous risks to this type of restoration.

PERIODONTAL HEALTH

Periodontal tissues need functional stimulation, and disuse will cause atrophy in the structures of the mouth just as in other parts of the body. Proper and sufficient intercuspation of the teeth are necessary for this stimulation. Premature wear, or grinding the teeth out of occlusion will prevent tissues from obtaining sufficient stimulation and will produce atrophy and destruction of periodontal structures because of disuse. By the same token, the excessive pressures needed to masticate food with improperly cusped teeth can cause occlusal trauma.

The cusp height of teeth in young individuals must also be borne in mind and the elements of balance considered in relation to the functional requirements of stimulation of the periodontal tissues.

The habit of bolting food after meager mastication, or of constantly choosing soft foods, will be evident in some mouths. The lack of detergence in the diet itself, and the general appearance of the mouth and teeth, and a careful history usually will identify the indolent eater. The indolence in mastication creates a weak, loose cancellous bone structure, as seen in the radiograph. This type of patient should be studied carefully to determine the feasibility of fixed restorations and their prognosis.

Careful consideration in clinical examination and study cast diagnosis will often reveal that harmful habits contraindicate construction of fixed appliances.

Clenching the teeth under stress or grinding (while asleep or awake) can cause failure of a restoration otherwise technically well made. Bruxomania and bruxism are primary causes of periodontal disease, and constant grinding on the hard gold of abutment crowns will very readily destroy the periodontal attachments of those teeth involved.

The periodontal aspects of fixed bridge failure cannot be considered only in the light of optimum function. Irritation plays a major part in destruction of tooth-supporting tissues and can be lumped under the general heading of "abnormal anatomy" in most of the bridge failures that we see. Basic tooth form, which is hardly capable of improvement over nature, *must be restored.* Marginal ridges must be capable of deflecting food in a direction away from soft tissues, and onto the chewing table, and cusp forms must be anatomic, even though they may be modified by making shallower inclines or adding accessory grooves. The only protection afforded the gingival margins on the buccal and lingual sides of the teeth is by deflection of food over the bulging contours of the teeth. If teeth are reproduced with thick cervical contours, where they should be constricted, or so positioned or tilted that this protective function is lost, a gingivitis will be continually recurrent.

CONTACT POINTS

The most important function of the contact point is the protection of the interdental papilla. Between anterior teeth were the papillae are conelike in form, very narrow or point contacts are all that are necessary. On bicuspids, a broader buccolingual contact area is required, because the crests of the papillae broaden out in this region. The molars require the widest buccolingual contact area, because the widest interdental papillae exist in this region. A point contact between fabricated molar crowns is one of the surest methods of tissue destruction, for as the interdental papilla goes, so goes the underlying septal bone.

When periodontal fibers are destroyed, or their attachments are severed during tooth preparation or impression making, a lasting stigma is evident. Consequently, in slicing the proximal surfaces with discs in preparng teeth for three-quarter or full crowns, all possible care must be exercised when the gingival crevice is entered. Also, when forcing compound onto the preparation while making an impression of it, undue forces against soft tissues must be avoided. However, a crown *can* be prepared as close to the fundus of the existing crevice as is technically possible without severing the periodontal fibers. The final requirements, however, are a perfectly fitting crown, and the thorough removal, before cementation, of all living and necrotic tissue between the tooth and the crown. The potential space between the crown and the tooth at the gingival margin (however small) must be eliminated completely, and all excess cement must be removed. Careful cementation technique is essential. The restoration should be worn temporarily so that the irritated soft tissue has a chance to recuperate from the abuse of the temporary crown. Then in cementation, the soft tissue at the gingival margin must be retracted, and the crevice made immaculate. If all these requirements cannot be

fulfilled, it is probably better to finish margins of the restorations short of the gingival margins, at least from the standpoint of eliminating gingival inflammation.

NUMBER OF ABUTMENTS

Frequently, fixed bridges fail because poor judgment was exercised in selecting the proper number of abutments to carry the load.

The total amount of periodontal attachments of abutment teeth must be estimated in relation to the number of pontics to be supported, and splints or double or triple abutments constructed where necessary. Obviously, when there is radiographic evidence of short or conical roots, those teeth should be classed as poor risks.

There is still a basic disagreement among the profession in relation to splinting, fixing bridges at both ends, and the use of multiple abutments. These arguments started when the advocates of the "tooth moves in function" school were condemning the completely fixed bridge. A perusal of the literature shows that there is still no universal agreement. In fact, some dental schools are still teaching students to construct cantilever-type or broken-stress bridges, with and without precision rests at the secondary abutment, and are outlawing the principles of splinting and complete fixation. One professor of crown and bridge prosthesis calls them periodontal appliances and has never seen an anterior splint (by his own admission) and does not believe that they are within the province of fixed prosthesis. Many clinics and articles have been presented with a theme based on the premise that fixed bridges (if they are made at all) should not include both anterior and posterior teeth, because the different types of function cause failure; or that only single tooth replacements are capable of long-lasting function.

As far as this observer is concerned, the completely fixed bridge is here to stay, and, for obvious reasons, a fixed bridge should be completely fixed. Splinting distributes occlusal stress and stabilizes teeth. Stabilization can *only* be established by fixation. The school of thought that rejects fixation on the basis of normal movements being limited is not seeing the whole picture. As a basis for these statements one is forced to go along with the best knowledge available in the science of periodontics. Miller[6] states, "Fixation and immobilization do not completely eliminate functional tooth movement. Regardless of how many teeth are splinted, the splint moves as a unit when masticating stress is exerted on it, and as a result, the peridental membrane is compressed, receiving a sufficient amount of stimulation to establish and maintain periodontal health." Also, Beube[7] showed cases of bone regeneration with splinting, when all other treatment failed.

It is interesting (to me, at least) that as long ago as 1926, Hardgrove[8] wrote: "There exists a great difference of opinion as to whether fixed bridges should be discarded in favor of movable-removable types. It has long been suggested that so-called fixed bridges do not move in function, *which is not true.* Fixed bridges *do* move, and what is more, if they are properly fabricated, move in the correct direction and just about enough.

"The fixed bridge re-establishes the lateral or proximal support and is a help to the life of the abutment, rather than a detriment."

With a whole generation of dentistry gone past and great advances in technique, Hardgrove leaves very little that can be added to his statement. But, twenty-seven years later, Smyd[9] has proved scientifically what Hardgrove learned by careful, meticulous technique and sound observation. Smyd found that the lug permits sufficient hinge movement of the primary abutment buccolingually with horizontal forces and mesiodistally with vertical forces. He states, "The looseness of the lug at the secondary abutment permits the tooth to turn distally on its own axis of rotation due to eccentric loading on the lug." The fact that destruction of periodontal tissue can be caused by compressive force is well known, and the conclusion then becomes obvious.

Stabilization and longevity are best attained by complete fixation. Smyd[9] takes this idea one step further and states, "The reason smaller abutments may be used with splint joint cantilever bridgework is that the foundational structures give. When the foundational structures pick up rigidity or stiffness, the abutments are wracked more and more and the cement gives way because it is the weakest link of the system. *But this proves the premise.* To offset the problem of structural failure, cut substantial abutments."

PATIENT EDUCATION

Technically perfect and well-planned and executed restorations fail because of lack of patient education. It is not merely sufficient to dismiss a patient from our care with mechanically and artistically beautiful restorations in optimum function. The patient must be made to understand that some of the factors that caused his tissue and tooth loss before treatment can still cause failure of that treatment. The patient must be impressed with the importance of periodic bite-wing and periapical radiographic examination, and with the importance of hygiene and home care. Proper methods of tooth and interproximal cleansing are necessary, and some method of massage of the soft tissues is always indicated.

Prinz[10] has said that massage causes cell activity and increased flow of blood, body juices, lymph and chyle.

Massage dilates vessels, stimulates circulation, and produces an artificial hyperemia in areas that do not have voluntary movement. Massage also causes nerves to induce muscular contraction in areas where voluntary movement is limited by nature or neglected by habit.

Strock[11] has designed a wheel-type brush that is caused to rotate by the brushing motion. It may be the answer to proper mouth hygiene when it is perfected. This brush not only cannot abrade enamel, but is ideal for the preservation of acrylic resin faces on veneer crowns.

SUMMARY

The various periodontal reasons for the failure of fixed prosthesis have been discussed, and the fundamentals of the biomechanical concept of dentistry have been emphasized in order to promote the success of fixed restorations.

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THE USE OF REVERSIBLE HYDROCOLLOID IN THE CONSTRUCTION OF THE PORCELAIN JACKET CROWN

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PORCELAIN IS THE FIRST choice of medium in the attainment of maximum esthetic appeal in dentistry. Unfortunately, however, on many occasions the esthetic superiority of porcelain must be sacrificed for a material, such as gold, in order to obtain proper function. In reconstruction, porcelain is an extremely difficult medium to use because of the great effort involved in achieving occlusal balance. When the anatomic crowns are short, gold must be used to eliminate the problem of breakage. Where porcelain crowns are constructed and are in occlusal apposition with gold, the porcelain will wear away the gold in time. The contraindications for porcelain are rather numerous. Yet in spite of this, the number of instances in which we can use porcelain is unusually high.

Since ceramics constitute such an important phase in the practice of dentistry, it becomes evident that more emphasis should be placed upon the development of techniques that will afford not only beautiful esthetic results, but also the accuracy of marginal fit and adaptation so readily obtainable in the construction of gold inlays and crowns. It is common knowledge that accurate fit and marginal adaptation are possible by the use of hydrocolloids, and it is the intent of this article to describe the use of this material as applied to ceramics. The procedure permits the achievement of a similar relative degree of accuracy as in the fabrication of inlays and crowns.

The limitations of compound tube impressions are well known. Regardless of the care used, one cannot be certain that some distortion of the impression has not occurred. Careless manipulation of the copper tube too often leads to severing of the gingival attachment; the packing of an amalgam die (or copper plating) presents further hazards; the placement of the die in a plaster, alginate, hydrocolloid, or rubber-base impression introduces still another possible source of error. It is amazing how a technique so full of possibilities of error could survive through the years as it has. It has survived mainly because of the fear of using stone dies in the construction of porcelain jacket crowns. The technique to be described will demonstrate that amalgam (copper- or silver-plated) dies are not necessary, and that the finished restoration can be produced without so much as chipping the stone die. If the die should be marred, however, it is of no consequence, since in this technique a duplicate die is provided to cover such an eventuality.

Read before the Alpha Omega Postgraduate Group, New York City, April 18, 1955.
Received for publication March 9, 1955.

PREPARATION OF THE TOOTH

It must be emphasized that this technique will provide nothing other than disappointment unless the operator produces excellent preparations of the teeth. The gross irregularities of the bur and stone cuts on the prepared stumps must be reduced to a minimum; the shoulders of the preparations must be smooth, uniform, and well defined. A maximum effort should be exerted so that there will be no difficulty whatever in reading the die. Careless preparations have no place in dentistry, particularly in a hydrocolloid technique which provides an unmasked picture of our efforts.

Important in the use of hydrocolloid is a coordinated effort in the preparation and handling of the material. Without the proper equipment, the use of hydrocolloid becomes a cumbersome affair, and a more or less hit-and-miss proposition. If the injection technique is to be used, the necessary syringes and trays are manufactured items. If the brush technique is preferred, a few show-card-type brushes (bent at right angles) and several four-ounce, widemouthed, Pyrex baby milk bottles are necessary. Of course, a conditioning unit for the hydrocolloid is indispensable. The conditioning unit makes it possible to be certain that the material has been properly boiled, stored, and tempered. A three- and a five-minute hourglass-type timer are necessary. Every step involved in the preparation and use of the hydrocolloid material must be carried out methodically; there are no short cuts to accuracy. As elementary as the foregoing may seem, the proper setup and the handling and preparation of the material cannot be overemphasized.

GINGIVAL RETRACTION

The gingival retraction phase of the technique requires the uncompromising patience of the dentist. It is not easy to achieve, but by the same token it is not impossible (Fig. 1). The procedure requires patience. There are a number of medicaments which are usable for this purpose; only my preference will be discussed.

An 8 per cent solution of zinc chloride has been found to be most satisfactory for gingival retraction. If this concentration of zinc chloride is used with discretion, there should be no concern about sloughing. It is suggested that the thread pack containing the zinc chloride be left in the gingival crevice for about a minute and then removed (Fig. 1,*A*). If at the end of this period retraction is incomplete it can be replaced with a fresh pack for another minute. In this manner, the dentist will learn how long a pack must be left in place in order to retract the gingival tissue to the point where the shoulder of the preparation is exposed. Careful application will avoid the danger of sloughing.

Two alternate solutions are always kept in readiness. They are a 1:100 solution of Adrenalin chloride, and a 8:100 solution of racemic epinephrine, either of which may be used instead of zinc chloride by preparing the cotton strips, just prior to usage. It should be noted, however, that even more patience will be required if either of these is used. In most instances, I use the zinc chloride pack for a minute or two, and then flood the region with the Adrenalin chloride or racemic epinephrine *a half minute or so* prior to removing the pack.

A spool of No. 8 white sewing thread is sterilized in an autoclave.[1] A number of 5- or 6-inch lengthss of the thread are cut and immersed in the astringent until they are soaked thoroughly. Then they are laid out on a glass slab until dry, after which they are stored in a labeled receptacle. A constant source of supply is thus always in readiness for immediate use.

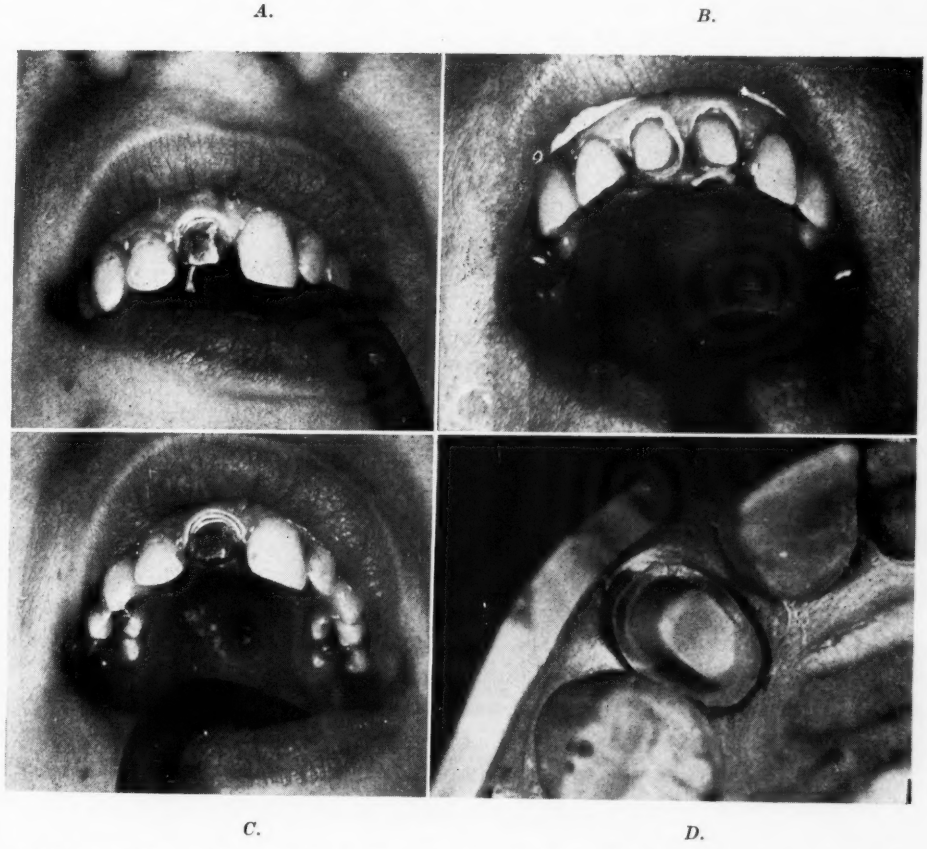


Fig. 1.—*A*, Thread impregnated with zinc chloride in place for retracting tissue. *B*, Multiple retraction. Note the expansion of the thread which is partially removed from the right central incisor. *C*, The thread is removed immediately prior to making the impression. Note the clear definition of the shoulder. *D*, The die and cast. Note that the shoulder is clearly exposed.

To obtain retraction of the gingival tissue, the tooth is protected from moisture with a cotton roll, and the area is dried carefully (Fig. 1,*B*). A piece of the impregnated thread is cut to the length which approximates the diameter of the cervical portion of the prepared stump. The thread is tucked *carefully* into the gingival crevice with a blunt instrument. The pressure is directed obliquely against the long axis of the tooth, rather than toward the apex of the root. (It is not necessary to tie a knot in the thread.) The thread is permitted to remain in place until the separation between the shoulder and the gingiva is completely established (Fig. 1,*C*). The impression is made immediately after the impregnated thread is removed.

IMPRESSION TECHNIQUE

A prerequisite to a good impression is clear access to the field of operation. This is best obtained by the use of cheek retractors and maximum lighting. Thus, a full view of the flow of the impression material is possible, the field can be kept dry, and the lips or cheeks can be kept from impinging upon the hydrocolloid impression material.

1. Three trays are used for each patient. Duplicate impressions are made of the prepared stump (or stumps), and one is made of the opposing teeth. The three impression trays are rimmed with high-heat compound prior to the retraction of the tissue, tried in the patient's mouth, and set aside. The compound is placed on the trays to (1) serve as an occlusal stop, (2) provide the means for securing a brass dowel (or dowels) to the tray, so that it may be related properly to the impression, and (3) serve as additional retention for the hydrocolloid.

2. Simultaneous with the completion of the placing of the impregnated thread into the gingival crevice, the tray is loaded with hydrocolloid, placed into the tempering bath, and the three-minute timer is inverted. When approximately two minutes have passed, the cheeks are retracted and the thread is carefully removed. The gingival area is dried thoroughly with gentle blasts of air. By the time this is accomplished, about three minutes will have elapsed and the assistant should be handing the loaded syringe to the dentist.

3. A small amount of the hydrocolloid is ejected from the syringe away from the stump in order to eliminate the partially jelled first portion. The nozzle of the syringe is placed carefully on the shoulder of the preparation, and a rather rapid circular motion is used while the hydrocolloid is injected into the gingival crevice, and around the shoulder, and then onto the stump itself. This procedure will avoid the trapping of air bubbles. The assistant *immediately* removes the tray from the tempering bath, and scrapes off the upper surface of the hydrocolloid with a knife. (The surface of the hydrocolloid takes up water in the tempering bath and it is very important that this water-contaminated material be removed so the material in the tray will form a solid union with that around the stump.)[1] The tray is seated and held gently but firmly in place. Care is taken not to move the tray from its initial position. The assistant then inverts the five-minute timer. The hydrocolloid is chilled for five minutes by water flowing through the tray very slowly. The slower the water flows the better, because it will cause the hydrocolloid to jell more uniformly throughout and reduce distortion.

4. When the chilling is complete, the impression is removed with a rapid movement in line with the long axis of the prepared tooth (or teeth) (Fig. 2). The impression is immersed in water immediately. A second impression of the preparation is made at once, and placed in water. Then the impression of the opposing teeth is made. All impressions should be poured as soon after removal from the mouth as possible.

When the impression of the opposing teeth is made, the teeth are painted with the diluted hydrocolloid prior to seating the tray containing the tempered hydrocolloid. In this manner, the trapping of air bubbles will be practically eliminated. The diluted hydrocolloid is prepared by placing a half ounce of boiling water in

the widemouthed Pyrex bottle, and adding a half ounce (or less) of freshly boiled hydrocolloid. The mixture is stirred thoroughly and stored in the conditioner. A fresh mixture of the diluted hydrocolloid should be prepared each week. The assistant can load the second tray two minutes after the first tray is placed in the patient's mouth, and then reinvert the three-minute timer. By this routine, the second tray will be ready to place moments after the first impression is removed. If this procedure is followed throughout, there will be no wasted time.

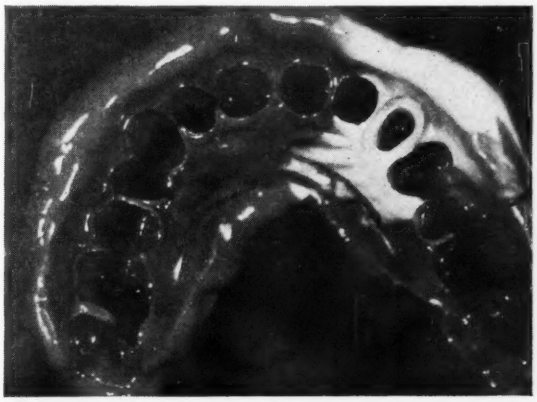


Fig. 2.—An impression of a preparation for a jacket crown for a cuspid. Note the fine detail obtained with hydrocolloid. Two colors of hydrocolloid were used for contrast.

POSITIONING OF THE DOWEL

While the impression is being prepared for the reception of the brass dowel (or dowels), a small bowl of water with some cotton should be kept handy. From time to time, the interior of the impression is moistened by using the cotton as a sponge.

1. A straight pin is placed across the impression so it rests on the modeling compound borders around the tray and not on the hydrocolloid. This pin is positioned so the dowel can be placed against it perpendicular to the center of the impression of the prepared tooth and parallel (if possible) to the adjacent teeth. The pin is secured at both ends with sticky wax. A drop of sticky wax is placed on the pin at the point where the dowel will be attached to it. While the sticky wax is still soft, the dowel is carefully luted to the pin (Fig. 3,*A*). The undercut head of the dowel should extend into the upper third of the impression of the stump, and the axis of the dowel is placed parallel to the long axis of the preparation and the adjacent teeth. This will avoid trouble when the dowel is removed later.

2. A second straight pin is placed across the tray in a similar manner, and attached to the other side of the dowel and to the compound rim (Fig. 3,*A*). During this procedure, the hydrocolloid must be kept well moistened with water. This is of particular importance, especially if multiple preparations are involved. Distortion will occur if the hydrocolloid is permitted to become dry.

TREATMENT AND POURING OF THE IMPRESSION

1. The impression is immersed in a 2 per cent solution of potassium sulfate while the stone is mixed. It should require about two minutes to prepare the stone mixture.

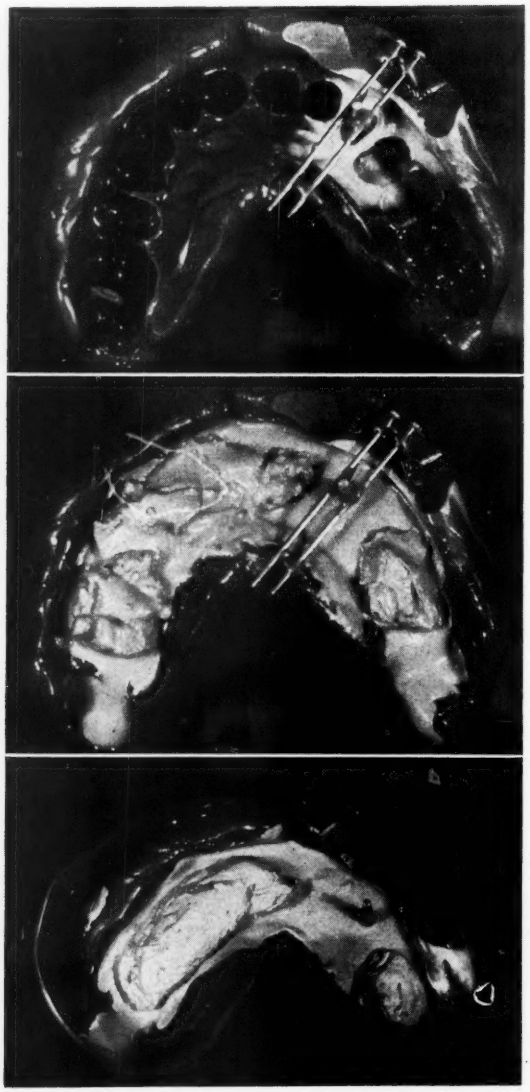
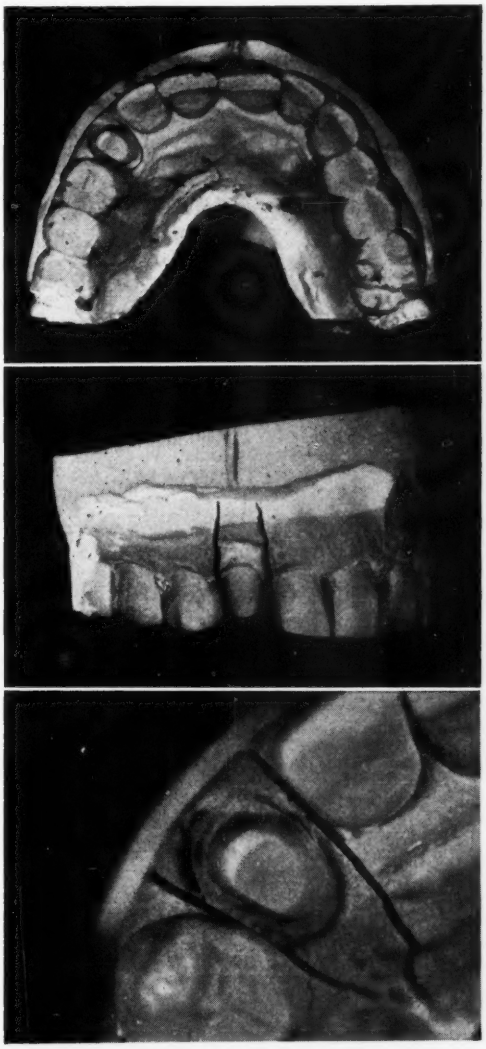


Fig. 3.—*A*, Pins are attached to the modeling compound rim on the tray for holding the dowel in position. *B*, The first half of the impression is poured. Note that the dowel-supporting pins are still in place. *C*, The pins are removed after the first mix of stone has set. The surface of the set stone is roughened and undercut, and the dowel and surrounding stone is lubricated. The impression is boxed ready for the second pour of stone.

2. A puttylike mix which will drip slowly from the spatula is made. When the proper consistency has been attained, a moderate quantity of the stone is placed on a clean dry towel and the excess moisture is blotted out.

3. The dried stone is vibrated carefully into the impression until all the imprints of the teeth have been covered, and the stone extends to a level a quarter of an inch or more above the undercut head of the dowel (Fig. 3,*B*). The exposed surface of the stone (except the die portion) is roughened, and undercuts are



A.

B.

C.

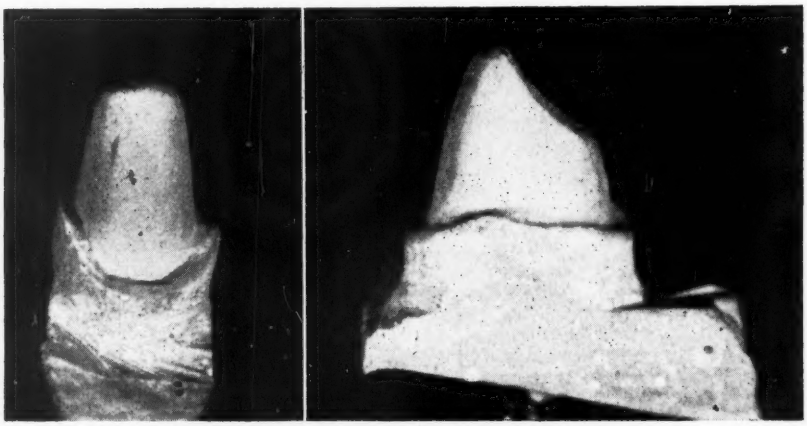
Fig. 4.—*A*, The completed cast. *B*, Saw cuts are made in the cast to separate the die from it. Note that stone of one color is used for the first pour and another color is used for the second pour. This serves as a guide for making the cuts. *C*, The cuts for removing the die have been made. Note that the shoulder of the preparation is intact.

created in this surface immediately after the die portion is poured. This will make sure that the second pour will attach firmly to the first. The poured impression is immersed in a 2 per cent solution of potassium sulfate at once, and permitted to remain in this solution for one-half hour by the clock.

4. The pins used to secure the dowel are removed. The dowel and that part of the stone just surrounding the dowel is lubricated. The impression is boxed and the second half of the cast is poured (Fig. 3,*C*). A contrasting color of stone is used for the second pour so the completed cast will be of two colors. The colors serve as a guide to the depth of the cuts that are necessary to produce the individual die (Fig. 3).

TREATMENT OF THE COMPLETED CAST AND DIE

1. After the stone has set completely, the cast is removed from the impression (Fig. 4,*A*). The bottom of the cast is scraped away until the tip of the brass dowel is exposed. This is necessary in order to study the path of removal of the dowel prior to making the cuts to separate the die. A fine gold saw (Trojan Jigsaw No. 36P) is used carefully to produce the interproximal cuts (Fig. 4,*B*). The stone used in the first pour is cut completely through. If this is not done, the die will be either impossible to remove or it will break (Fig. 4,*C*).



A. *B.*

Fig. 5.—*A*, The stone die has been removed and trimmed. *B*, Note the clear definition of the shoulder.

2. The tip of the dowel is tapped gently and the die is removed from the cast. The gross excess of stone around the portion of the die (the part extending ¼ inch or more below the shoulder) is removed with a heatless stone. A No. 11 Bard-Parker blade is used with the aid of magnifying loops to fine-trim the die so that a slight smooth divergence of stone exists entirely around the shoulder. The same shape is desired on the stone die that would be formed in an amalgam die, so that a swedged platinum matrix may later be removed without distortion (Fig. 5).

The duplicate cast is left intact (without cutting the stone for the removal of the die). In this manner, a twofold purpose is served: (1) The exact gingival contour is conserved to serve as a guide in shaping the jacket crown so that impingement on the gingivae will become impossible. (2) The immovable die permits the

accurate establishment of the contact points. The second cast is cut only if an accident occurs to the master cast or die.

The advantages of the procedure are obvious when the die and cast are complete. There are no fuzzy surfaces on the teeth, and there are no familiar scratches, cracks, and missing corners which result from plaster impressions. The die is very accurate and seated in the correct relationship to the adjacent teeth. The important proximal surfaces are complete and perfect so it is unnecessary to scrape them. Precisely fitting contact points are developed with ease. Occlusal adjustment is kept to an absolute minimum since the opposing cast is also obtained with hydrocolloid.

For those who fabricate porcelain jackets in their own laboratories, there is but one precaution necessary. After the platinum matrix has been adapted in the routine manner (as for metal dies) (Fig. 6), the Moldine used in the swedger must be fresh, moist, and of uniform consistency. For those who use a commercial laboratory, this information will be useful in the forwarding of proper instructions. From the laboratory point of view, the use of hydrocolloid for porcelain jacket construction means fewer remakes.

Fig. 6.—The platinum matrix has been swedged and burnished over the stone die.

MULTIPLE JACKET CROWN PREPARATIONS

In the construction of multiple jacket crowns this use of hydrocolloid becomes even more valuable, for it eliminates practically all of the errors which become progressively greater in alternative techniques. The technique involved in the construction of multiple jacket crowns is the same as that described except for two steps.

The first is in the method of gingival retraction. Where several jacket crowns are to be constructed (Fig. 1,*B*), the first gingival packs must not be left in until all gingival crevices have been packed. The gingivae around each tooth must be examined as time passes, and when retraction is complete the pack is removed from that particular crevice and is continued around the other teeth. Gingival sloughing may result where the packs are left in too long.

The second is in the placement of the brass dowels. Care must be exercised to see that each dowel is perpendicular to the center of the preparation and also parallel to each adjacent dowel. Two pins are used to secure each dowel (Fig. 7). When multiple jacket crowns are made, full (rather than partial) trays are used. The complete cast is an invaluable aid in establishing the proper esthetics of the restorations.

With a little experience, the hydrocolloid can be injected around as many as six preparations without any concern of premature gelation before the tray is placed. The resulting cast will be accurate.

DIFFICULTIES WITH OTHER TECHNIQUES

A properly constructed porcelain jacket is difficult to achieve, for we are concerned with two vital factors: the over-all accuracy and the equally important esthetics. Earlier techniques would not permit us to achieve such a degree of over-all accuracy, and at the same time, by virtue of the character of the resultant casts, make it possible to achieve the proper esthetics.

Much chair-time has been wasted because of crowns which fit the amalgam (or copper-plated) dies but not the patients' teeth. Many more hours have been wasted because of crowns lacking the proper contact points, malalignment of crowns, and repeated breakage which result from inaccurate die relationships.

Too often jacket crowns have had to be returned to the technician because a contact point has been overground. This means a complete remake or another bake and, if it is the latter, further weaknesses can be created in the restoration.

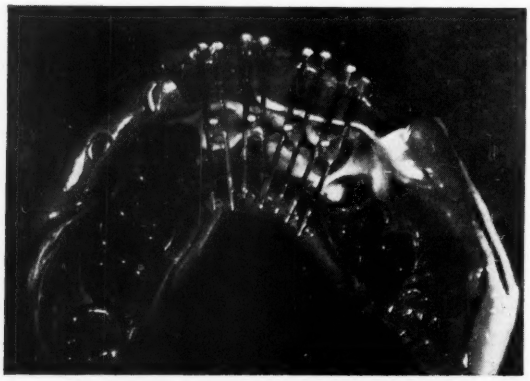
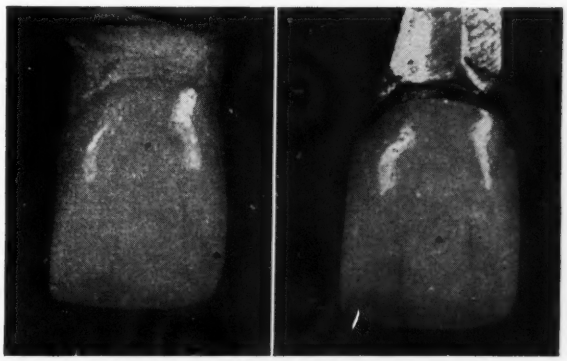


Fig. 7.—The pins are in place to retain dowels in a parallel relationship to each other when an impression is made for multiple jacket crowns.

Malalignment of the die, which occurs as each laboratory step is completed, leads to further inaccuracies. Many times a new impression is made and with a degree of uncertainty as to the end result. On other occasions, correction of the crown is attempted by the addition of more porcelain, which, in turn, means another bake which may cause weakness. Too often a jacket crown is ground to correct a discrepancy, thus destroying the fine glaze, and in order to save chair-time, the crown is cemented without reglazing.

The judicious use of porcelain is most important and depends upon a proper diagnosis. Assuming that good judgment is exercised, the next most important preventive of breakage is in the accuracy of the fit of the crown. Frequently, when a jacket crown breaks from inaccuracy of fit, another replacement is made from the same die, with the consequence that breakage recurs (Fig. 8).

Experience has proved that hydrocolloid is capable of producing an accurate replica of the prepared tooth. This means that a jacket crown made by the technique described will follow every contour of the preparation. This will add the strength so necessary to so fragile a restoration as a porcelain jacket crown after it has been cemented.



A. *B.*

Fig. 8.—*A*, A jacket crown constructed on a stone die which was made from a hydrocolloid impression. Note that the crown does not seat completely on an amalgam die of the same tooth made in a copper-tube-compound impression. *B*, The crown in position on the stone die. Note the complete contour and the adaptation to the stone die.

SUMMARY

It is not to be inferred that it is impossible to obtain an accurate impression of a prepared stump with the copper-tube compound technique. A technique for making impressions for porcelain jacket crowns in hydrocolloid has been described, and it is offered as a substitute which provides assurance that accurate dies and well-fitting porcelain jacket crowns can be produced with a greater consistency than with compound. Remakes with hydrocolloid are so few that they are negligible.

The one disadvantage (if one may call it so) of the suggested procedure is that some time is required for the laboratory work necessary to produce the casts and dies, but the chair-time that is saved eventually compensates for this extra laboratory time. The correct marginal adaptation and over-all accuracy of fit is far more important than the element of time.

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A LABORATORY AND CLINICAL INVESTIGATION OF CERTAIN RESIN RESTORATIVE AND CEMENTING MATERIALS*

Part I. In Vitro Tests on Adhesive Characteristics

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THE ADHESIVE CHARACTERISTICS of dental restorative and cementing materials have been the subject of several investigations.[1] Work by Berkson[2] with zinc phosphate cement indicated that adhesion between this type of material and tooth structure, in the true chemical sense of the term, does not exist. Any retentive characteristics could be attributed to the bonding of irregular surfaces rather than a molecular attraction between unlike molecules.[1-3] In recent years, the advent of resinous materials for restorations and for the cementation of inlays, crowns, etc., has stimulated further research in this area. Many claims have been made for the adhesive characteristics of some of these products. Certainly adhesion to tooth structure would be a most desirable feature. It would tend to minimize the practical effect of contraction during polymerization and would reduce any tendency for marginal leakage from temperature change or stress on the restoration.

There is no established test for adhesion, and various experimental techniques have been used. Fiasconaro[4] studied adaptation by measuring the resistance to air pressure. Christie[5] has measured adhesion of filling resins to a number of substances, while Stuben[6] and Bartram[7] described methods for measuring adhesion between a filling material and tooth structure. A report by Swartz and Phillips[8] has described a method for measuring adhesive characteristics of cementing materials and some data presented indicated greater adhesive properties for resin cements than zinc phosphate cements on a prepared dry dentin surface. However, the deleterious effects of exposing resin cements or zinc phosphate to moisture were shown. Rose[9] and Wileman,[10] using somewhat different test methods, corroborated these observations.

It is apparent from the published research that many of the resin materials which have been tested do possess greater adhesive characteristics than zinc phos-

Portions of this article were read before the Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 5 and 6, 1955.

From the Departments of Dental Materials and Crown and Bridge.

Received for publication March 10, 1955.

*This research was supported in part by a grant from the L. D. Caulk Company, Milford, Del.

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phate cements but that the detrimental influence of moisture must be taken into consideration when evaluating them from a clinical standpoint. Many claims are still made concerning the adhesion of certain products to tooth structure, regardless of the dryness of the cavity preparation or the environment to which they are exposed. Since there is no data available to indicate whether there is a difference in various popular products, the following investigation was conducted. It was the purpose of the study (1) to evaluate the adhesive characteristics to both enamel and dentin of various popular resin filling and cementing materials and (2) to study the effect of certain other variables, such as cavity primers.

PROCEDURE

The method for measuring adhesion has been described in a previous publication[8] and will not be discussed in detail. In general it involved a tensile type test in which a gold post is cemented onto a flat dentin or enamel surface, and the tensile load required to pull the post off of the tooth is measured. Various variables such as consistency of the mix, thickness of the film, and method of applying the load have all been studied and standardized. It is recognized that this test does not necessarily conform to the exact type of stress to which a restorative material or the cement on an inlay may be subjected in the oral cavity. However, the method does provide a most suitable technique for studying adhesion, per se, of various materials to tooth structure, and certainly a material which provides a high tensile stress before separation would seem to be superior in terms of adhesion to tooth structure under actual clinical conditions.

The crowns of sound extracted teeth were ground flat to expose a disk of either enamel or dentin, depending upon the particular test being conducted. After mounting in the metal holder, the surface was carefully prepared by means of an airbrasive machine, using the cutting abrasive, in order to prepare a uniform surface. The specimens were routinely examined for any signs of chipping, fracture, or irregularities which might produce error. Teeth were replaced frequently. All tests were run at mouth temperature and the load was applied at a constant rate of 576 lb./in.^{2} per minute.

Certain popular resin filling and cementing materials were selected and purchased on the open market. These were felt to be representative, and no attempt was made to include all the popular brands. Several batches of each product were used as the test period extended from January, 1954, through January, 1955. The products included were as follows:

Restorative Material	*Manufacturer*
Kadon	L. D. Caulk Co.
Sevriton	The Amalgamated Dental Co., Ltd.
P. F.	American Consolidated Dental Co.

Cement	*Manufacturer*
Grip	L. D. Caulk Co.
Justi Resin Cement	H. D. Justi
Smith's Resin Cement	Lee Smith Co.

In the data presented in this paper, these materials will be referred to as code letters rather than by the trade names. The filling materials are lettered as A, B, and C while D, E, and F are the cements. They are not necessarily lettered in the same order as they are listed above. Constant changes are being made in all these materials, particularly in the amount and type of filler materials. Consequently, by the time this article is published, results with current batches might be somewhat different.

A minimum of 15 specimens was run with each material and the mean value is reported. It is true that there is considerable variation in individual specimens,[8-10] but results are readily duplicated by using the mean strength of a sufficiently large group. The tensile strength, and thus the adhesion, is expressed to the nearest hundred pounds per square inch.

Tests were conducted storing the specimen at normal room humidity and in tap water. The test period generally was one hour. It has been shown that resin materials seem to reach their maximum adhesion at that time.[7, 8] Duplicate tests were also made using a cavity conditioner* designed to improve adhesive characteristics. This same agent was used for all materials except Sevriton, in which case the "cavity seal" recommended by this company was used.† It is recognized that this particular agent may not be best suited for each commercial brand of resin due to variation in the composition, concentration of catalysts, etc. However, only these two liners are commercially available at the present time, and since the purpose of this phase of the study was merely to evaluate the general benefit, if any, of such a material, this one liquid was employed for all brands except Sevriton.

RESULTS

Dentin.—The mean data obtained on dentin can be seen in Table I. When the specimens were stored in air and the cavity primer not used, there was little difference in adhesion of any of the products except for filling material C which was

TABLE I. DENTIN

RESIN	1 HOUR AIR		1 HOUR H_2O	
	NO PRIMER	PRIMER	NO PRIMER	PRIMER
A	1,400	1,800	600	800
B	——	900	—	300
C	800	1,600	900	700
D	1,300	1,500	500	700
E	1,300	1,300	500	800
F	1,500	1,200	700	1,000

*Caulk cavity primer.

†In this article the term primer will arbitrarily be used to designate these two agents.

considerably lower. (Product B was not tested for adhesion without the primer.) However, when the primer was applied to the surface before cementation, the adhesion of this product was increased approximately 100 per cent and is comparable to the other materials. Product B, even with the use of the primer, is approximately 25 per cent below the next material.

It does appear that the priming agent did generally improve the adhesion. This is even more pronounced when the specimens were stored in water for one hour. The strength was improved for each material, except C, by the use of the priming agent. The deleterious effect of moisture with all materials is again demonstrated.

Enamel.—When enamel was used as the test specimen (Table II) some products showed different adhesive characteristics than with dentin. For example, filling material C, in a dry atmosphere, was more effective on enamel, but the tensile strength of product B was lowered. The beneficial effect of the priming agent is generally more pronounced than it was on a dentin surface, particularly when the specimen was not stored in water. When the storage time in water was increased to 16 hours, all three of the products tested showed very low adhesion. and in the case of C, the specimens actually separated during storage.

TABLE II. ENAMEL

RESIN	1 HOUR AIR		1 HOUR H_2O		16 HOURS H_2O	
	NO PRIMER	PRIMER	NO PRIMER	PRIMER	NO PRIMER	PRIMER
A	300	1,200	300	300	200	100
B	——	600	——	400	—	—
C	1,200	2,000	300	600	0	0
D	1,300	1,800	1,000	1,000	—	—
E	1,000	1,600	1,200	1,100	200	100
F	1,700	2,000	900	1,000	—	—

It is apparent then that adhesion to enamel as to dentin is influenced by moisture to the same degree. Likewise, the data indicate that there is a difference in the adhesion of some materials to enamel or dentin, and that although the priming agent is generally beneficial in improving adhesion, its effectiveness is dependent upon the particular resin and whether the surface is enamel or dentin. The mode of action of this primer is not known. That it actually does combine with the organic phase of the tooth has been suggested.[11] These data, of course, do not substantiate or refute that research. It may be that these agents merely improve the mechanical retention by penetration into irregularities in the tooth surface or by actually wetting the surface. For that matter, the exact mechanism why resin materials show greater adhesion than zinc phosphate is also not known.

Standard deviations were calculated for all materials and the values were comparable to those reported previously.[8] There was considerable variation between individual specimens, and no one particular product was superior from this standpoint.

Damp Surface.—In all the tests made, the tooth surface had been carefully dried by air and acetone before application of the cement. Another series was designed to determine the influence of a slight film of moisture on the tooth surface. Enamel was used, and the specimens were stored for 15 minutes in water immediately before cementation of the gold post. The surface was dried by an air syringe and the cement then applied.

The data can be seen in Table III. If these figures are compared to the values obtained on a dry surface (Table II), it can be seen that the adhesion was generally decreased, with or without the application of the primer. The reduction was particularly pronounced with product C. Since the test conditions here probably do not represent great differences from the actual clinical cavity preparation, the necessity of thoroughly drying the preparation, and maintaining a dry field of operation is essential if maximum adhesion is to be attained. Clinically, difficulties have occurred whenever moisture was present or could not be eliminated.[12, 13] The data again emphasize the beneficial action of the priming agent.

TABLE III. EFFECT OF CONDITIONER ON A DAMP SURFACE

RESIN	1 HOUR AIR—ENAMEL DAMP SURFACE	
	NO PRIMER	PRIMER
B	——	500
C	600	1,300
D	1,300	1,200
E	1,400	1,600
F	1,200	1,600

Character of Enamel Surface.—It has been shown that zinc phosphate does not adhere as well to a highly polished surface as to a rough one.[2] To determine the influence of this variable on the adhesion of resin materials, a series of tests were made on a polished enamel surface. The polishing was done metallurgically, and the final surface was attained by use of a wet polish wheel. The teeth were repolished before each series of tests. Two materials were employed, and the results are seen in Table IV. Compared to the results on a roughened surface (Table II), the adhesion is somewhat reduced. For example, when stored in air and the primer used, the strength of material A was lowered 300 lb./in.^{2} and 600 lb./in.^{2} when stored in water. These results would be anticipated. However, the differences obtained were not great, and the data would suggest that something

other than a mere roughening or etching of the surface would be required to achieve marked increase in adhesion. Likewise, the results here are of interest since they emphasize again the adhesive tendencies of these materials even when the surface is highly polished. These might suggest something other than a mere mechanical interlocking of the cement into irregularities.

TABLE IV. ENAMEL

RESIN	1 HOUR AIR		1 HOUR H_2O	
	NO PRIMER	PRIMER	NO PRIMER	PRIMER
A	300	900	100	300
D	1,000	1,200	800	800

DISCUSSION

This investigation has shown that with the materials tested, no one particular product showed any marked superiority in adhesion to enamel or dentin. One product (B) proved to be lower in most of the tests. It is doubted that, on the basis of these data, any particular material could be cited as definitely being inferior or better than the others tested.

The results have shown the dissipation of the adhesion to either enamel or dentin when the specimen is exposed to water. Claims that a material will adhere tenaciously to a wet surface are unwarranted. There is no doubt that adhesion of all of the current products, as well as zinc phosphate cement, is influenced by moisture. It should, however, be remembered that this is a heroic and greatly accelerated type of test. The stress applied is a drastic one from that applied to the filling or cementing material in the mouth. The surface exposed to water is great and conditions are optimum for penetration at the margins. The low surface tension of water, as compared to saliva, and the flat specimen would allow maximum penetration by capillary action. Thus, it is difficult to transpose these data into the practical significance under clinical conditions. This problem is inherent with the other in vitro studies which have been made.[4–10] All of these studies, and the data here, have clearly demonstrated that moisture does play a vital role in the maintenance of adhesion to the tooth. Whether this reduction of adhesion would take place in the oral cavity under the conditions which are present, and the exact length of time to reduce the adhesion down to a value comparable to zinc phosphate cement cannot be answered by a laboratory test. Clinical observations[12, 13] indicate that adhesion not possible with zinc phosphate cement is secured and maintained.

However, these data and the test method can be utilized to great advantage in determining the influence of basic variables in the manipulation and insertion of these materials, and to compare the adhesion of various experimental formulas. There is merit to a test which is so demanding. If a material can be designed which

will produce marked improvement in adhesion compared to those now in use, then this laboratory tool will demonstrate that ability in a quantitative manner.

True adhesion to tooth structure, and more specifically to the enamel, would be of inestimable importance to restorative dentistry. Marginal leakage, present in all restorations,[14, 15] would be greatly reduced. It is in this area that truly epoch-making advances may eventually be forthcoming.

CONCLUSIONS

A study of the adhesive characteristics of three popular filling and cementing resinous products has shown: (1) there is no marked superiority of any one particular product; (2) moisture has a deleterious effect with all materials as adhesion was reduced whenever the tooth surface was not dried thoroughly; (3) the adhesion of a given product to enamel may differ from its adhesion to dentin; (4) the conditioning agent was generally beneficial in securing and maintaining maximum adhesion.

The possible clinical significance of these data was discussed.

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A LABORATORY AND CLINICAL INVESTIGATION OF CERTAIN RESIN RESTORATIVE AND CEMENTING MATERIALS

Part II. A Twenty-eight Month Clinical Evaluation of a Resin Cement*

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IN A PREVIOUS PUBLICATION[1] it has been pointed out that, from the viewpoint of many workers in the field of dental materials, the primary weakness of any cast restoration lies in the soluble zinc phosphate cement which is used as a luting material. Naturally the less precise the fit of the casting, the greater is the margin of cement which is exposed to the saliva and the sooner such a margin would deteriorate from dissolution of the cement. The resinous materials which are now being used as cementing media may offer some advantages over the zinc phosphate cements on the basis of laboratory tests[2, 3] and objective handling characteristics. If properly compounded without an excess of certain filler agents, they are less soluble than the zinc phosphate cements, and their manipulation is possibly less subject to human variables than that of the zinc phosphate cements.

Thus, from the standpoint of the laboratory investigator, these characteristics of the resin cements, plus possibly greater adhesion to the enamel and dentin surface,[2, 3] make them appear to be somewhat superior to the luting materials which have been in common use for many years. Since all laboratory studies must be corroborated by clinical evaluation, it seemed feasible to initiate an extensive clinical trial of a resin cement. The possible advantages and disadvantages were now recognized,[1-3] and thus it was necessary to determine the clinical manifestations of these properties. Such a study was initiated in the Crown and Bridge clinic of the Indiana University School of Dentistry.

PROCEDURE

In the twenty-eight months since this study was inaugurated, more than 300 bridges have been seated using a resin cement. During the first year several experimental formulas† were used; then upon the introduction of one commercial brand

From the Departments of Crown and Bridge and Dental Materials.
Received for publication March 10, 1955.
*Read before the Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 5 and 6, 1955, and read in part before the International Association for Dental Research, Chicago, Ill., March 18, 1955.
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†Supplied by the L. D. Caulk Company, Milford, Del.

of cement* it was used exclusively. Approximately 750 retainers and 170 individual units, such as jacket crowns, gold veneer crowns, individual PV crowns and pinlays have been cemented. The number of facings retained by resin cement approaches 500.

During the first twelve months of this investigation, all restorations were seated without the use of a priming agent, and without the application of cement to the prepared tooth surface. The tooth was wiped clean with cotton and alcohol, then dried with warm air. Laboratory tests had shown this to be a desirable procedure.[3] No adverse pulp reactions were brought to our attention. The mixture was placed inside or on the tooth surface of the retainers and the appliance seated. When the in vitro tests proved that the priming agent was beneficial in securing maximum adhesion,[3] this agent was routinely used. During the last eighteen months, the cement has also been applied to the prepared tooth surface as well as onto the cavity surface of the castings and plastic crowns. The utmost care was always exercised to keep the area uncontaminated by moisture. The manufacturer's directions were carefully followed, although it is probably true that the adhesion is not greatly affected by the power-liquid ratio.[2, 4] Pressure was maintained on the cemented restoration for a period of four to five minutes.

Before discussing the results, a few statements might be made regarding the level of the student endeavor, and how, in our opinion, it compares with that generally accepted by the dental public. With some exceptions, the abutment teeth are prepared better by the student and the supervising instructor than by the majority of men in practice. Except in "desperation" cases, there are few gross marginal discrepancies, and when they do exist they tend toward short margins rather than overhanging ones. The castings have surprisingly good fit, marginal and otherwise. In the hands of a few students, contour and occlusion is good, but, with the remainder, they are what the students are forced to produce. Since many of the bridges seated in dental offices are fabricated in commercial laboratories, many of them are overcarved. Bridges made by students generally are the opposite.

Due to student efforts to restore occlusion, and because of the mistreated oral apparatus found in college clinical patients as compared to those encountered in a general private practice, it is probable that the bridges seated in our clinic will be subjected to more adverse thrusts and torque than those seated in practice; but, on a comparative basis, the bridges from which the following observations were made are quite possibly of a somewhat higher level of quality than many seated by the practicing profession. It can be accepted that the better the fit of the cast retainer, the thinner the line of cement exposed at the margin; and certainly the better the preparation of the abutment tooth, the less efficiency is required of the cementing material in order to keep the cemented bridge or crown in position on the tooth. Inasmuch as it is assumed that these factors are superior in the tested samples, it must also be assumed that the major portion of the practicing profession might not always experience the same results shown in this study.

*Grip resin cement.

RESULTS

It has been possible to check approximately 100 of the bridges, some for the third and fourth times, and approximately 70 of the individual units. The 300 retainers, 240 facings, and the 70 individual units make a total of approximately 600 cemented units observed and in satisfactory condition at the present time.

Effect of Certain Medicaments.—Much difficulty was experienced with cemented posts in root canals. One or more of the drugs used in the endodontic treatment prevented the polymerization of the resin, and the posts invariably pulled out with the copper band impressions. It is now standard procedure to use zinc phosphate cement for this operation. Also, some jacket crowns loosened. In almost every instance, the prepared tooth stump had been covered with zinc oxide and eugenol, or with a temporary crown with a eugenol dressing next to the tooth. This is a fatal procedure with resin cement unless the tooth is scoured lightly with pumice, and wiped with phenol, then moistened by alcohol and dried with warm air. Although this method has not been followed in the clinic, three men reported that they use it and have encountered no serious sequelae.

For several years, a member of the faculty had worn a well-made but badly designed lower bridge extending from the second molar to the first bicuspid. Due to a combination of circumstances, the molar required endodontic treatment. This was done without disturbing the cavity outline of the second molar preparation. The cavity portion of the abutment was filled with cement and the bridge was reseated. Being soldered to the second molar inlay with a rest in the bicuspid inlay, the bridge came out regularly every three months. The patient was busy, was waiting for the endodontic treatment to prove itself, and consequently this situation existed for a period longer than was necessary. After four cementations with zinc phosphate cement, the resin cement was used. Four months elapsed before the bridge became loose, and the same period of time passed before the bridge was unseated for the second time. The experiment was continued and each of four cementings with resin cement resulted in the same period of service, with only a slight variation. The bridge has been remade.

Recemented Bridges.—Records have been maintained on several defective bridges which were temporarily recemented. Six were cuspid-to-cuspid replacements, retained by PV crowns, with varying lever arms and length. Due to a number of factors, the PV crowns had distorted and some of the metal covering the incisal edges was burnished away. Histories or records showed periods of service ranging from eighteen months up to eleven years.

Each bridge was replaced with resin cement after being cleansed as well as possible. The teeth were freed of any debris and surface caries and were dried by phenol and alcohol, followed by warm air. The priming agent was used in all but one instance.

One of the six remained in place for four months, when the patient was assigned for the reconstruction of the prosthesis. This bridge was the best prospect, having the least distortion, the best prepared abutments, and the shortest lever arm. Removal necessitated cutting the crowns and prying the halves sufficiently to produce voids. It is our considered opinion that the bridge was more difficult to remove than

if zinc phosphate cement had been used as the luting material. Another bridge stayed in position for ten weeks until removed for reconstruction. This one was removed by using a reverse mallet crown remover. On one end the crown slipped off of the cement, while, on the other, the cement adhered to the metal, removal from which required cutting with a bur. The cement remaining on the tooth was removed with a chisel and a scaler. Initial circumstances would indicate that this might be the result. The cement adhered to a thick and unyielding casting that fitted loosely over an abutment which had a carious surface, and which had been dried with warm air but not dehydrated. The cement remained on the tooth under the thin casting that was elastically deforming under a cusp excursion. This bridge was not exceedingly difficult to remove, and showed some indication of moisture infiltration. Obviously this was merely an objective observation.

A third bridge remained seated for eleven weeks and was removed readily by use of the reverse mallet. Since the teeth had been covered with a eugenol dressing before the bridge was replaced, the cement adhered to the metal.

During the period of waiting for assignment (ten to twelve weeks), the remaining three bridges required recementing, one of them three times. While the caries in these abutment teeth was no greater than in those previously mentioned, the margins of the castings left wider cement lines, the lever arms were longer, and the cast retainers were less adequate to resist springing forces. At the time of removal for reconstruction, one was loose at one end and the other two offered little resistance to the mallet or to removal of the cement from the teeth.

The bridges with full crown retainers, which were replaced temporarily, remained seated. When removed for reconstruction some difficulty was experienced. It was necessary to cut the crowns and pry the pieces from the cement. (Except in two cases the cement was removed from the teeth only after considerable effort.) These were posterior bridges with short lever arms and minimal torque.

Two broken-stress inlay bridges, each from lower second molar to second bicuspid, were recemented. While it was felt that cavity preparation and wax pattern adaptation were responsible for these coming loose, there were other factors which contraindicated reconstruction of the same design. One remained seated for nine weeks, at which time the patient was assigned to a student. The other required recementing after about one month, possibly due to careless manipulation by the assigned student.

Plastic Restorations.—A few practitioners have reported occasional discoloration under plastic jacket crowns when resin cements were used. One of the authors (J.F.J.) examined five specimens in one office and two in another, and felt that these failures were due to one or more of the following reasons: (1) poor shoulder preparation which resulted in an insufficient bulk of material in the crown, thus permitting distortion; (2) open margins permitting rapid loss of adhesion; (3) very poor condensing and curing of the plastic crown; (4) removal of the excess cement before polymerization was complete, resulting in pulling some of the material from under the crown margin. This could happen if the crown were not entirely free of the stone used in flasking.

Two jacket crowns constructed in the clinic have loosened, apparently due to a lack of parallel walls and insufficient support of the incisal portion of the restoration. One constructed in the clinic discolored, probably a result of poor cementing technique.

New Bridges.—Five of the approximately 300 bridges cemented in our clinic have come loose. One did so because of poorly prepared abutments and faulty occlusion. After repreparing the supporting teeth and reconstructing the retainers and pontics, with more care being given to establishing the occlusal relationships, the bridge has remained seated now for sixteen months. No priming agent was used in this instance. The other four failed to remain seated on one end because of poor technique in cementation. Although priming agents were used, it was felt that the teeth were not adequately prepared for cementation. It was possible to remove two of these bridges and recement them, after cleansing the retainers and the teeth. The remaining two could not be removed, and it was necessary to destroy the cemented retainers in the removal. Even then removal was difficult, more so than if zinc phosphate cement had been the luting material.

For a variety of reasons, it has been necessary to remove two single unit gold crowns and three inlays where the resin was used for cementation. None had been in the mouth for a long period, but no leakage was evident. Again removal was not easy. In these cases there was a definite retentive quality evident, as well as good apparent sealing of the cavity margins.

DISCUSSION

With the well-designed restoration and an exacting casting, both zinc phosphate and resin cement have performed well in the oral environment. Some of the characteristics of a resin cement which were demonstrated in laboratory tests[2–5] do not seem to be borne out under clinical use. For example, the dramatic loss of adhesion when specimens are exposed to tap water has not been corroborated in this study, at least for the period of observation. Reasons for this possible discrepancy have been discussed.[3] It has not been the purpose of this investigation, nor would it be possible, to determine the mechanism of the adhesion or adaptation of the resinous cement to the tooth surface.

To date the observations made in this research have indicated that a resin cement, at least the one used here, because of apparently greater adhesion to the tooth surface under clinical conditions may prevent leakage more successfully than zinc phosphate cement. However, it should be recognized that the profession now has two types of materials available which, if used carefully, will perform adequately.

CONCLUSIONS

After approximately twenty-eight months of clinical use and close observation of resin cements as a luting material for a large number of crown and bridge restorations, the following conclusions seem valid at this time:

1. The resin cement which was used showed greater adhesive characteristics clinically than did zinc phosphate cement under the same conditions.

2. The cement used in this study could be displaced to a sufficiently thin film thickness, since no bridge has failed to be seated provided it could be seated before the cement was applied.

3. The cement cannot be used to adjust shading to the same degree as can zinc phosphate cement, but color stability is satisfactory once cementation is completed.

4. Working characteristics are better than with zinc phosphate cement, inasmuch as there is slightly more working time and the mixing technique is less critical. An earlier toilet of the area is necessary with the resin cement, especially in the embrasures; otherwise removal of the excess can be quite difficult.

5. Noticeable pulp reaction, following cementation, is absent unless the abutment teeth have not been sufficiently protected. It then appears to be no different from that following the use of the zinc phosphate cements.

6. It does not apparently fracture under pressure. This is an opinion which as yet cannot be substantiated by sufficient data.

7. From observation of several open margins around castings which had sufficient bulk to prevent deformation of the metal, no solubility of the cement in oral fluids could be detected.

8. Resin cement reacts unfavorably in the presence of some drugs used in dental operations. When it is known that such medicaments have been used, resinous materials should not be applied.

9. Tissue tolerance of the resin cement may be better than that shown zinc phosphate cement.

10. Laboratory tests and clinical use have shown resin cement to be equal to zinc phosphate cement except under a very few specified conditions, and superior to it under others.

The results found here must not be construed as a recommendation that, with the use of a resin cement, standards of cavity preparation, dryness of the field or fit of the casting can be minimized.

We wish to acknowledge the assistance of Dr. Donald Cunningham and Dr. Roland Dykema in supervision and evaluation of the clinical studies.

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HYGROSCOPIC TECHNIQUE FOR INLAY CASTING USING CONTROLLED WATER ADDITIONS

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IN 1933, SCHEU[1] INTRODUCED a dental gold casting technique utilizing the hygroscopic expansion property of dental casting investment. Since that time, there has been a gradual increase in interest of the dental profession in this method of compensation. It has been felt that this reaction by the profession is a manifestation of a present-day need and desire for better and more accurate methods for the making of a dental prosthesis of cast gold. Whether or not hygroscopic casting techniques satisfy this need has been a controversial issue.

By definition, the hygroscopic expansion phenomenon occurs whenever a mixed mass of dental casting investment, while undergoing the setting process, is brought into intimate contact with water, maximum expansion usually resulting if contact is made as soon as possible after the mix has been made. Since all dental casting investments show some degree of hygroscopic expansion,[2] it can easily be seen that hygroscopic expansion will occur in all techniques that utilize a wet asbestos liner adapted to the inlay ring before the investing procedure. As a consequence, it can be stated that all inlay casting techniques utilize the combined result of setting, hygroscopic and thermal expansion to compensate for the casting shrinkage of gold. Those techniques deriving their major source of compensation by thermal expansion are commonly called thermal techniques, whereas those utilizing mainly hygroscopic expansion are called hygroscopic techniques. The technique being described in this article is a hygroscopic technique.

Unfortunately, to be able to make a precisely fitting casting is not the answer to the gold casting problem; unless such a result can be reproduced casting after casting and achieved by the average practitioner. It has been felt for some time that although some very capable and skillful operators can produce perfect castings with any technique, their results cannot be reproduced consistently in the hands of many dentists or dental students. Some recent work[3] on an evaluation of dental casting techniques, however, has shown that hygroscopic techniques have some merit as far as reproducibility of compensation is concerned. In that investigation, based on linear measurements of castings, a hygroscopic technique indicated seven very reproducible castings out of a series of nine, whereas other techniques showed four at best. Another investigation[4] based on a clinical evaluation of fit of castings made by several casting techniques also showed the hygro-

These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Michigan (NR 180-360).

Presented in part before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 6, 1955, and the Dental Materials Group of the International Association for Dental Research, French Lick, Ind., March 21, 1954, and Chicago, Ill., March 20, 1955.

Received for publication March 21, 1955.

scopic procedure to be more reproducible. It is significant to recognize that in each of these studies on casting technique evaluation, no castings were discarded once the test runs had begun. However, the lack of complete reproducibility in these conventional hygroscropic techniques as well was also apparent from those studies. In view of these results, it appeared desirable to investigate further the utilization of hygroscopic expansion as a major compensating factor in the dental gold inlay casting procedure, and specifically to determine if greater reproducibility could be achieved.

This article is a result of this desire for improvement and, in essence, describes a hygroscopic technique which is, in general, similar to the hygroscopic techniques which are presently being advocated, but in one detail significantly different; this detail is the method in which the environmental water is supplied to the investment in order to allow for the hygroscopic phenomenon. Present techniques are the "water-bath" technique in which the setting investment is immersed in a water bath immediately after mix,[1] and the "wet asbestos liner" technique whereby water is supplied to the investment by the asbestos liner which had been saturated with water prior to the investing procedure.[5] The technique about to be described involves the addition of a specific or controlled amount of water to the investment.

PRINCIPLE OF CONTROLLED WATER ADDITION

The principle of adding a controlled amount of water to the investment was derived from a study[6] whose results may be summarized as follows:

1. *The amount of hygroscopic expansion of a dental casting investment is directly related to the specific amount of water which the investment absorbs or, synonymously, to that amount of water which may be supplied or added to the investment subsequent to mixing.* An unlimited amount of water available, such as in the water-bath technique, results in the maximum possible expansion, whereas lesser amounts of water result in less than maximum expansion. In Fig. 1 is shown the relationship between the expansion and the amount of water added to a dental casting investment. A straight-line relationship exists from a point representing zero water added and normal setting expansion, to a point representing the maximum amount of water which the investment will pick up and the resulting maximum hygroscopic expansion. This latter point has been called the "critical point" for the particular investment and conditions under which the experiment was conducted. It represents the point beyond which further water addition results in no further increase in expansion.*

Another significant result which can be seen from the relationship of linear expansion to amount of water added in Fig. 1 is the excellent proximity of the experimental points to the straight line drawn through them. It has been shown[6] that the average deviation of expansion values resulting from controlled water addition is of the order of 0.1 per cent, whereas the average deviation for complete im-

*In reference 6, the curves drawn indicated an inhibition, or decrease, in expansion with water added in excess of the critical point. However, a later evaluation of the data and curves resulted in the conclusion that this effect was due to the method of test rather than a manifestation of a phenomenon related to the behavior of the investment. This, however, does not invalidate the results up to and including the critical point.

mersion or a wet asbestos liner procedure is of the order of 0.3 per cent. The reasons for this differentiation of reproducibility are not obscure. It is felt that the critical relationship between water supplied and resulting expansion precludes accuracy in the case of the wet asbestos liner since it is difficult to incorporate the same amount of water into the liner for each test or for each casting procedure. In the case of water-bath immersion, as will be demonstrated presently, the maximum capacity of the investment for water pick-up and expansion is influenced by manipulative and other variables which can easily result in irreproducible results. Aside from these comparisons, the reproducible nature of the expansion resulting from controlled water addition is, in itself, one of the major factors in justification of a compensating technique based on this principle.

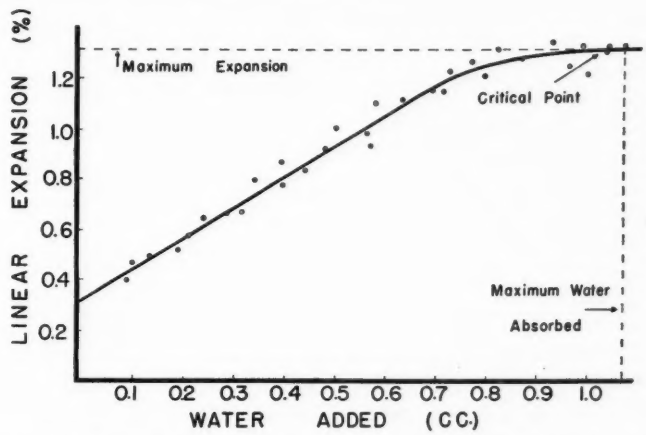

Fig. 1.—Hygroscopic expansion versus water added for a dental casting investment; illustrating the dependence of hygroscopic expansion on the amount of water added and the presence of a "critical point."

2. *Hygroscopically expanding investments have limiting capacities to pick up water and expand. This limit is called the critical point and is affected by water/powder ratio, conditions of spatulation, and the natural variables of the investment, such as age and differences from one manufactured batch to another.*

In Fig. 2, the effects of water/powder ratio, spatulation and age of investment are shown. For this particular investment and under the conditions of water/powder ratio of 30/100 and a spatulation of 100 turns, which is a so-called normal mix, the critical point occurs at a maximum expansion value of about 1.6 per cent.* If it were to be presumed that this value represented an expansion which was just sufficient for compensation, it can be seen easily from Fig. 2 that the effects of the variables indicated, in their reduction of the critical point, will result in insufficient compensation when a water-bath technique is used. A thinner mix as well as a lesser amount of spatulation both tend to decrease the capacity of the investment for water pick-up and subsequent hygroscopic expansion, and, as a result, the critical

*This value as well as others to be quoted are those measured from the time when the external dimensions of the investment begin to increase which is not necessarily the time when the mold cavity begins to enlarge. At present, there is no established method of determining the true expansion of the mold cavity. The initial set time is most commonly used as a fiducial point but this also is arbitrary in nature.

point is lowered. Aged investment or that which has been contaminated with moisture over a period of time exhibits a decrease in capacity for water and thereby a lowering of the critical point, as is indicated. Although not shown on the curve in Fig. 2, often a change in batch number will result in a slightly different capacity for expansion or variation in the position of the critical point. This may be due to manufacturing variables, such as the physical make-up of the ingredients which is beyond the control of the manufacturer. Since the water-bath technique utilizes the critical point for its expansion value, it is not difficult to see that irreproducibility may occur.

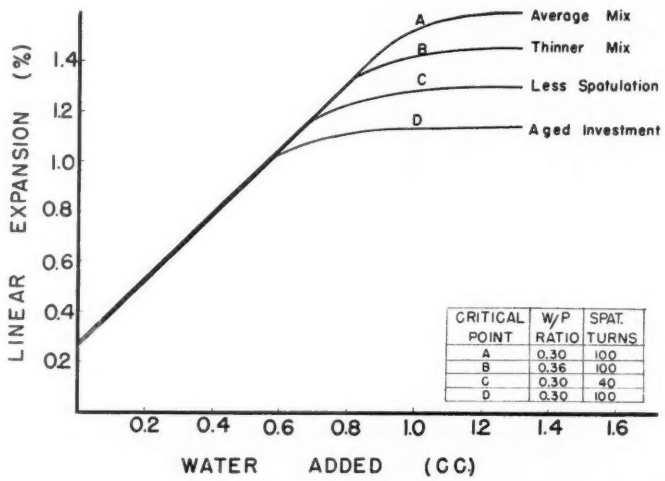

Fig. 2.—Hygroscopic expansion versus water added for a dental casting investment as a result of change in water/powder ratio, spatulation, and age of investment; illustrating the lowering of the critical point.

3. *Within limits, variations in water/powder ratio, spatulation, age and batch number of investment do not significantly affect expansion values which result from adding water below the critical points established for these variables.* These are other salient features of controlled water addition, which are in striking evidence in Fig. 2. All of the curves for the conditions of average mix, thinner mix, less spatulation, and aged investment are coincident below the critical points. The expansion which results from adding water below point D, for example, will be the same regardless of water/powder ratio, variation in spatulation or change in the investment due to aging.* This, then, is the obvious criterion for the amount of water to be added in a controlled water-added technique; namely, that the amount of water added must be below the critical point. Unfortunately, a casting procedure based on controlled water addition using the investment of Fig. 2 would not be successful, in that the amount of expansion which resulted from a water addition below point D would not be sufficient for complete compensation. Accordingly, the solution to this problem is in providing an investment with a sufficiently high

*An exception here is for abnormally thick mixes which tend to increase slightly the slope of the curve as evidenced in reference 6.

critical point under normal conditions such that, if variable factors drop the critical point, it will not fall below the expansion required for compensation. It was at this point of investigation that a meeting was called of manufacturers of dental casting investments who might be interested in compounding such an investment. Both the Ransom & Randolph Company of Toledo, Ohio, and the Whip-Mix Corporation of Louisville, Kentucky, were interested, and have since placed on the market

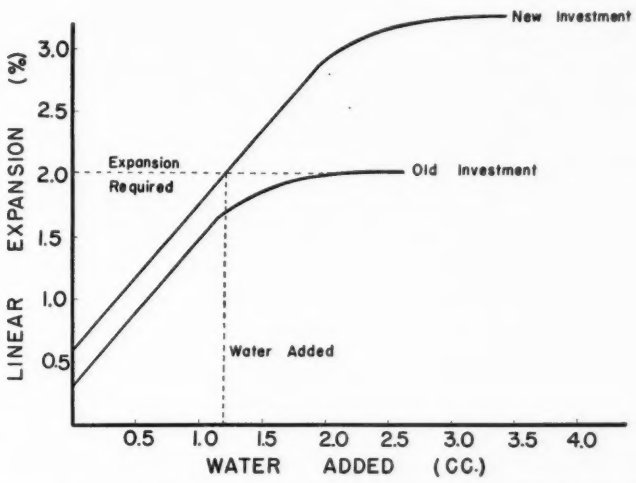

Fig. 3.—Hygroscopic expansion versus water added for a modified (new) investment to be used for the "controlled water added" technique as well as for an investment (old) used for the "water bath immersion" technique; illustrating a marked increase in critical point for the modified investment.

investments suitable for a controlled water-addition technique. In Fig. 3 is shown the curve for one of these modified investments and its relationship to an investment used for the water-bath technique. The extremely high critical point of this material makes it especially suitable for a controlled water-addition technique, but not for a water-bath technique.*

The significance of the results of this discussion of the principle of controlled water addition can be demonstrated best by listing the three main advantages upon which the merit of this water-added technique is based.

1. The effects of influencing factors such as water/powder ratio, spatulation conditions, age and batch number of investment are eliminated.

2. A convenient and accurate means of changing the expansion is provided by the addition of different amounts of water. By adding greater or lesser amounts of water, the expansion may be increased or decreased without changing the water/powder ratio, spatulation or immersion time, factors which have been advocated for this purpose in the past with other techniques.

3. More than adequate reproducibility of the investment expansion is achieved by adding a controlled amount of water.

*It is conceivable that this investment may be used for the water-bath technique if the water/powder ratio is increased considerably (thinner mix) and the spatulation is held to a minimum.

DESCRIPTION OF EQUIPMENT

In discussing the actual technique using controlled water addition, it is important to recognize that the only basic difference in procedure between this technique and other hygroscopic techniques is in the method of presenting water to the setting investment. Instead of immersion of the inlay ring in water, or lining the ring with wet asbestos, a controlled amount of water is specifically added to the investment. Only minor equipment alterations and additions were necessary in order to carry out this modification. Since an asbestos liner would absorb some of the added water, the elimination of this item was necessary; yet, some means had to be provided to allow for unrestricted expansion. A flexible inlay ring was developed as a solution of this problem. In Fig. 4 is shown the original equipment designed for this purpose. As is shown, a ring made of Korogel was molded to approximate, in inside dimension, the size of an average inlay ring. A recess was provided in the bottom of the ring to accommodate a sprue base so as to provide an airtight seal. Water is added to the investment by means of a syringe calibrated in tenths of a cubic centimeter. The amount of water required for a given expansion depends on the original volume in the inlay ring; a greater or lesser volume requiring greater or lesser amounts of added water to yield the same percentage of expansion. Therefore, some means was necessary to insure the placement of the same amount of investment into the ring each time. This was accomplished by filling the ring with investment (flush with the top) and then inserting a small brass ring called a reservoir, so as to form a reservoir for the added water. In addition to the flexible ring, sprue base, reservoir, and syringe shown in Fig. 4, a section of metal tubing is also pictured which fits the outside dimension of the Korogel ring and is used to prevent its collapse if and when vacuum procedures of investing are employed. In fact, it was found desirable to place this tubing around the Korogel ring even while hand investing, as its rigidity facilitates the investing procedure. In Fig. 5 is shown the assembled equipment and the manner in which the controlled water addition is affected.

Both the Ransom & Randolph Company and Whip-Mix Corporation are manufacturing rubber rings and the other necessary equipment for this technique, and they are currently available through the dental trade. The design of this manufactured equipment is based on the originally designed equipment shown in Fig. 4.

It can thereby be concluded that no elaborate, complicated, or expensive equipment is required to employ the controlled water-added principle.

DESCRIPTION OF TECHNIQUE

Before using the controlled water-addition technique, it is well to read carefully the manufacturer's instructions accompanying the investment and equipment purchased. However, a general procedure of technique will be presented which is based on the originally designed equipment.

After the sprued pattern is mounted on the sprue base, the flexible ring is placed around it. The investment is mixed and placed into the ring by either hand-mechanical or vacuum investing procedures. If vacuum is used, the sup-

porting metal tubing must be placed around the ring prior to investing but removed immediately afterward. If this metal ring is allowed to remain around the flexible ring, the expansion will be restricted, and proper compensation will not be effected. The flexible ring is then filled, and the level of investment is struck off flush with the top of the ring. The reservoir is placed in position and the required

Fig. 4

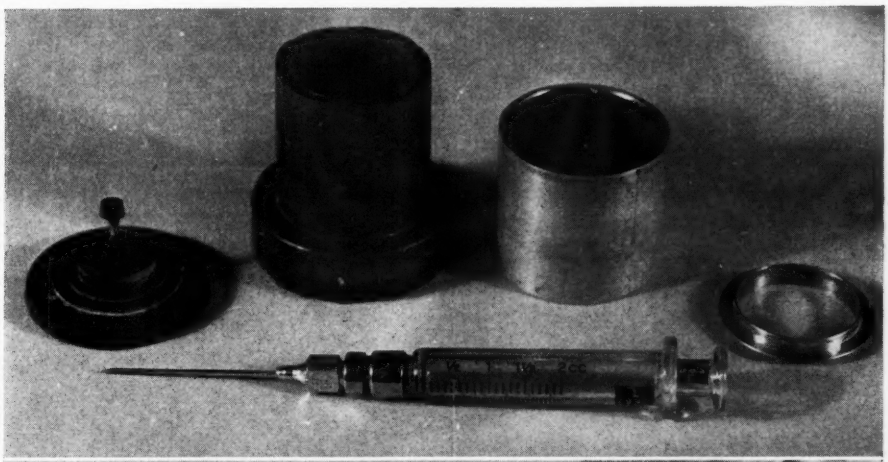

Fig. 5.

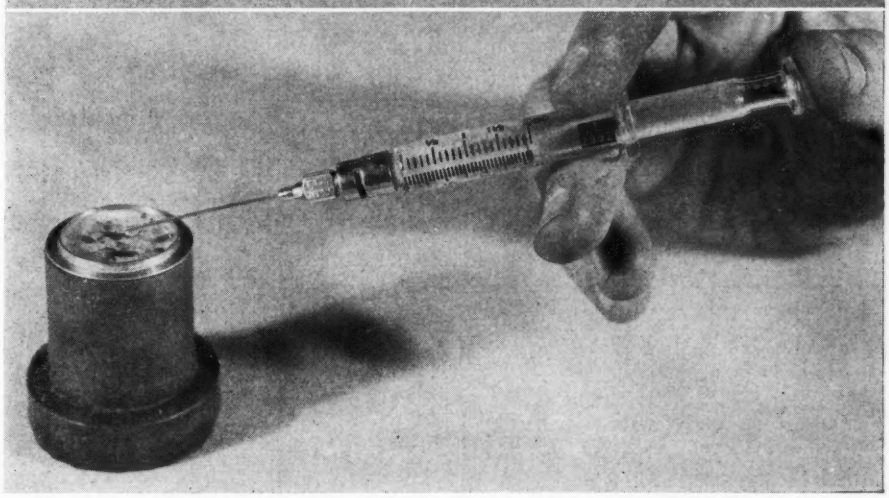

Fig. 4.—Original equipment designed for use in the "controlled water added" technique. Consists of a sprue base, flexible ring, supporting ring, reservoir, and syringe.

Fig. 5.—Manner in which a controlled amount of water is added to the investment immediately after the investing procedure.

amount of water is added. The exact amount of water to be added is given in the manufacturer's instructions for the investment being used. After 45 minutes' time, the flexible ring, reservoir, sprue base, and sprue pin are removed, thereby leaving the cylinder of investment which conformed to the inside of the rubber ring. The

wax is then eliminated by placing the investment mold for at least one hour into an oven preheated to 850°F. The use of a rubber syringe and boiling water bath for wax elimination is discouraged when using this technique, since without a surrounding metal ring, excessive flow of hot water through the investment may result in an erosion of the mold cavity and rough castings. A tight-fitting rubber ring placed around the investment cylinder will eliminate this difficulty. However, this procedure is unnecessary if an oven burnout procedure is used, which has proved itself completely adequate for the job. After burnout, the casting is then made into the investment cylinder. Since no outside metal ring is used for support, the investments used for this technique must be sufficiently strong to resist the impact of the molten gold as it is thrust into the mold in centrifugal casting procedures. The strengths of both new Ransom & Randolph Hygroscopic Investment and Whip-Mix Hygrotrol at the W/P ratios recommended are adequate for this purpose.

One of the advantages of the water-bath technique results from the usage of water warmed to 100° F. Both setting and hygroscopic expansion can be restricted by wax patterns of the enclosing type, such as the MOD and full crown, whereby the strength of the wax tends to inhibit the expansion of the investment core. The 100° F water bath softens the pattern during the expansion period, thereby preventing this restriction. This effect is most pronounced in very large patterns having especially heavy occlusal sections, as well as narrowly tapering walls of large dimension; but it is not perceivable in castings of average dental size and shape. The temperature of the bath may also induce warpage in the wax pattern before the investment is set, if the pattern contains excessive strains; this is a possible disadvantage of this technique. If the operator is in favor of this procedure, the flexible ring used in the controlled water-addition technique may be immersed in a 100° F. water bath to allow for this effect. The water level of the bath should, of course, be below the top of the ring to prevent any additional water being supplied to the investment. Since the increased temperature will increase the dimensions of the wax as well, the amount of water added must be reduced. This reduction is about 0.4 c.c., and this value should be checked with the manufacturer's instructions. A dry-air oven may also be used to accomplish the same purpose, but due to its inefficiency in heat transfer in comparison with the water bath, the temperature should be increased to possibly 135° F.

These procedures have been mentioned since questions concerning them do arise in discussions of modern inlay casting techniques. It has been found, however, after making several hundred castings, that the normal cavity preparations confronting the dental practitioner can be quite suitably fitted without the application of heat during the setting process.

EVALUATION OF THE CONTROLLED WATER-ADDITION TECHNIQUE

The three main advantages of this technique have been stated as being: (1) reduction in effect of influential variables, (2) the facility for changing the compensation if desired, and (3) reproducibility of results. These advantages were derived from the results of expansion measurements made on dental casting invest-

ment. To be practically significant, these results should be corroborated by results achieved with actual castings. The castings about to be illustrated and described are part of more than 400 castings made using the controlled water-addition technique, and were used in a general evaluation of the technique. Of particular interest are those castings used to substantiate the three main advantages of the technique as previously stated, and they are described as follows:

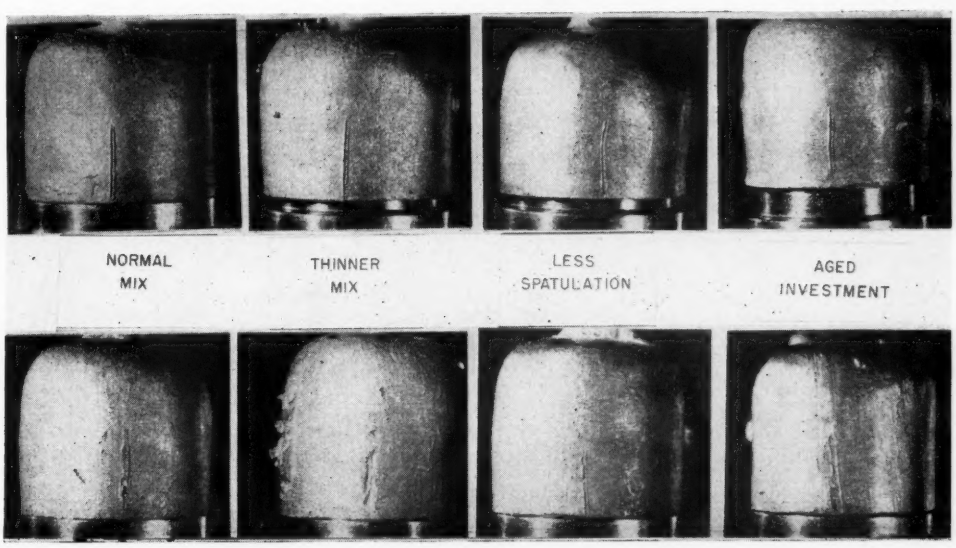

Fig. 6.—Effect on casting fit due to changes in water/powder ratio, spatulation, and age of investment for the "water-bath immersion" and "controlled water-added" techniques.

1. *Reduction in Effect of Influential Variables.*—Referring again to Fig. 2, it can be seen that the critical point for a normal mix (*A*) drops as the mix becomes thinner (*B*), less spatulation is used (*C*) and as the investment ages (*D*) (going from critical point *A* to critical point *D*). Since the critical points represent the maximum capacity of the investment to pick up water and expand, the water-bath technique should reflect these decreasing expansion values. In Fig. 6, top row, are shown four full crown castings made under the conditions of immersing the ring in a water bath immediately after mixing. The conditions of test were the same as that shown in the curve of Fig. 2, normal mix, thinner mix, less spatulation, and aged investment. These tests were run on a hygroscopic investment which was designed for the water-bath technique. For a normal mix, an acceptable fit is shown. However, variations in water/powder ratio, spatulation, and age of investment are shown to result in inadequate compensation. Variation in batch number has a less pronounced effect, and cannot be easily demonstrated by illustrative means. However, after making many castings, the effect of this variable was quite easily detected by the feel of the fit of the casting on the die, or the difference between a condition of retention and lack of retention.

Also shown in Fig. 6, bottom row, is a series of castings made using controlled water addition. The investment used was one of the new hygroscopic investments whose critical point for a normal mix had been raised considerably. The effects of thinner mix, less spatulation, and aged investment, although decreasing the critical point, did not lower it below the expansion point necessary for adequate compensation when the same amount of water was added for each casting. As can be seen, all four castings, although made under varying conditions except for amount of water added, demonstrate the same acceptable fit.

2. *Facility for Changing the Compensation, if Desired.*—There has always been much conjecture as to whether all patterns require the same amount of expansion for the same degree of fit. The Phillips control technique in its very extensive treatment of varying expansion with pattern size and shape has demonstrated the necessity for this observance. Advocates of hygroscopic techniques, however, have postulated that all patterns should be compensated for equally, and the water-bath technique has never observed any distinction between pattern shape or size. Other techniques of more recent origin have been advocating the placement of the ring, during setting, in a dry-air oven set at 135° F. with no further consideration being given to pattern shape or size. It would appear from these brief observations that the rigidity of the wax pattern may be the main factor in consideration of changing compensation for different patterns. However, other factors which affect fit serve to complicate the picture. Factors such as surface roughness, will most certainly have a greater effect in a casting of very slight taper compared to one having a large amount of taper. The answer to this problem apparently lies in the opinion of the individual operator. An acceptable fit as judged by one practitioner may be unacceptable to another.

In the controlled water-addition technique in which no water bath is normally used, two different expansions are advocated; one for two surface restorations, and a slightly higher expansion for all other types of restorations. This amounts to a difference in water addition of about 0.1 c.c. The exact amount of water to be added should be taken from the manufacturers' literature.

The most significant point, however, is that the expansion can be changed simply by adding a greater or lesser amount of water. Additions or subtractions by tenths of a cubic centimeter can be shown to affect the casting fit; the amount of effect depending on pattern shape, size, and taper. In Fig. 7 is shown a full crown type of casting in which the controlled water added was decreased by intervals of 0.3 c.c. from the point of adequate compensation to that corresponding to no water added, or no hygroscopic expansion.

3. *Reproducibility of Results.*—It has been shown that the reproducibility of the investment expansion as measured by the average deviation is of the order of 0.1 per cent.[6] The next step in the evaluation procedure then, is to see if casting accuracy substantiates this order. The usage of a wax pattern and the casting procedure itself serves to complicate an evaluation of compensation accuracy. However, in the study by Suffert and Mahler,[3] many of these variables were eliminated by the simple expedient of measuring a strain-free pattern and the subsequent casting without regard to the fit of the casting on a die. The measurements were

made to small marks placed in a one-surface type of die which were reproduced in the wax pattern and gold casting. This procedure was followed for the data shown in Table I. The average deviation is shown to be 0.1 per cent.

Although the value of an evaluation based on casting fit to a die must be mitigated by factors such as wax pattern distortion, surface roughness, frictional factors between casting and type of die material used, and others, an evaluation would not

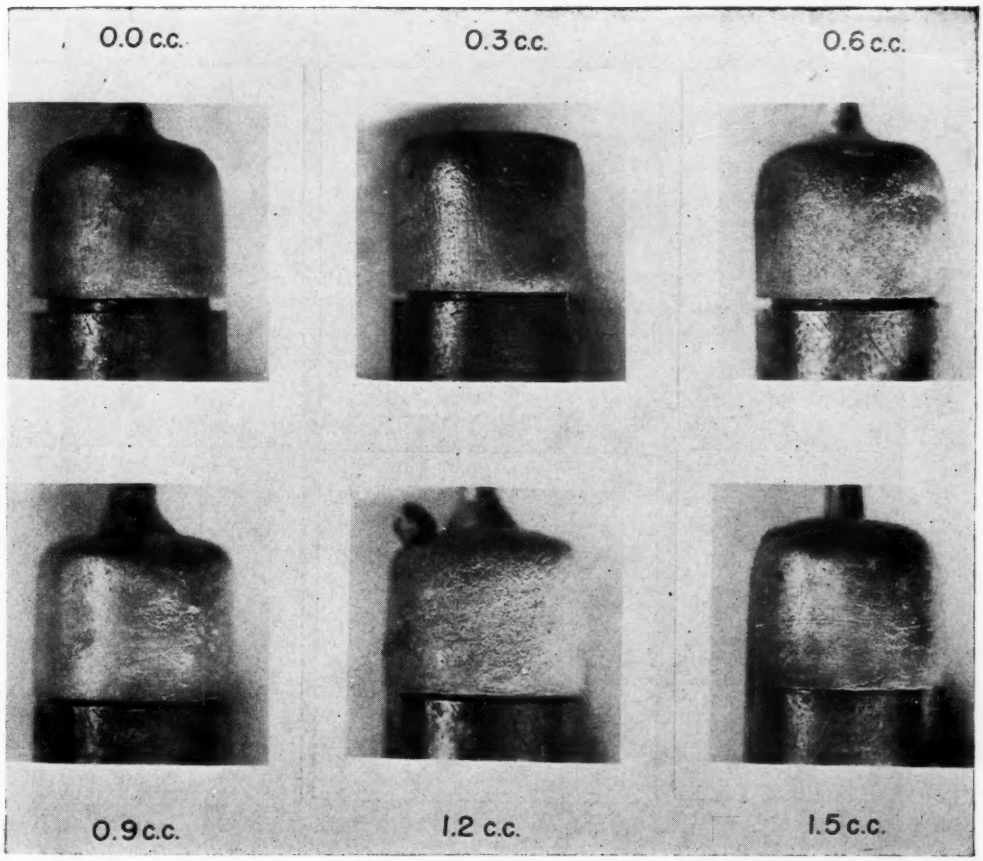

Fig. 7.—Effect on casting fit of changing the amount of water added to the casting investment.

TABLE I. REPRODUCIBILITY OF CASTINGS MADE BY THE CONTROLLED WATER-ADDED TECHNIQUE
PER CENT

Run Number	Gold Measurement minus Wax Measurement
1	+0.2
2	−0.1
3	+0.1
4	0.0
5	+0.1
6	−0.1
Average Deviation	0.1

be complete unless many practical castings were made. In Fig. 8 are shown castings made to fit three different cavity preparations—Class I, full crown, and three-quarter crown. Each preparation was reproduced in a dental stone die five times, and a casting was made for each of these dies. The fit of all of these castings was

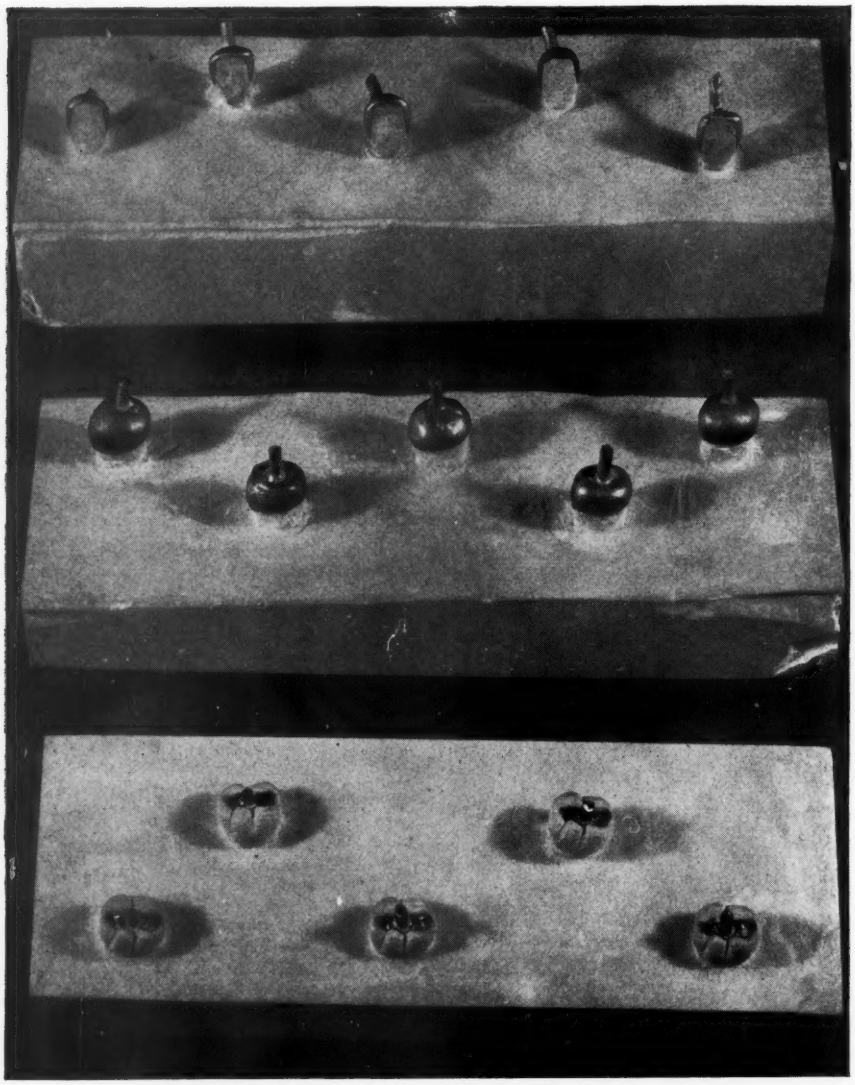

Fig. 8.—Series of castings made on gypsum dies indicating reproducibility of casting technique.

judged to be excellent. These are a small percentage of the total number of castings made in which metal dies were used, as well, and other types of cavity preparations investigated. Many clinical castings have also been made and the results have been quite acceptable.

In conclusion, a few remarks concerning the evaluation of an inlay casting technique are in order. Too often, a new technique is extolled and received by the profession as a panacea for the inlay casting problem. This attitude is inconsistent with the facts. As long as any technique is based on the "lost wax" principle, the problems and variations which accompany making the wax pattern, investing the pattern, burning out the mold, and casting the gold must be contended with; not to mention impression making and die fabrication if the indirect method is employed. It would be fallacious to think otherwise. The procedure which was followed in making the castings for this study was considered to be consistent with present knowledge of inlay casting technique. No special procedures were used other than a degree of care deemed necessary for any gold casting technique.

SUMMARY

In summary, a hygroscopic technique for dental gold inlay casting has been described which is based on the results of a fundamental study[6] of the nature of hygroscopic expansion. It was found in this study that the amount of hygroscopic expansion which occurs when a specific amount of water is brought into intimate contact with a dental casting investment during setting is directly related to or defined by this amount of water. In addition, a critical point was found to exist which represents the maximum capacity of the investment for water pick-up and subsequent expansion. Water added below this point was found to define precisely the concomitant expansion. A hygroscopic technique based on the results of this study was designed. It features a flexible inlay ring in order to eliminate the asbestos liner, yet not restrict the expansion, as well as a calibrated syringe for adding controlled amounts of water to the investment during the setting process. The advantages of this technique which were established in the measurements made on investment in the previous study[6] and corroborated by the results of practical castings as reported in this study, are stated as follows:

1. The effects of influencing factors such as water/powder ratio, spatulation conditions, age and batch number of investment are eliminated.

2. A convenient and accurate means of changing the expansion is provided by the addition of different amounts of water, if such a prodecure is desired by the operator.

3. More than adequate reproducibility of the investment expansion, and subsequent casting fit is achieved by adding a controlled amount of water.

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The Readers' Round Table

New York, N. Y.

Editor, The Journal of Prosthetic Dentistry:

In Joseph S. Landa's article, "An Analysis of Practices in Mouth Rehabilitation," (J. Pros. Den. 5:527-537, 1955), I found much that I can agree with, especially the precautions against "bite-raising." On the other hand, there are many findings with which I disagree. For example, I cannot see why "multiple splinting . . . makes further treatment of these teeth by the periodontist difficult because of the difficulty of access to the pockets." However, I would like to limit my disagreement in this letter to his definition of mouth rehabilitation. While very little space was devoted to this in the article, it is a matter of considerable importance whether this approach to treatment is to be given the dignity of a special phase of dentistry or is to be equated with routine procedures like amalgam fillings.

Prophylaxis, amalgam fillings, and MOD inlays when needed are obviously important in the care of a mouth in which the dental units are in an arrangement sufficiently harmonious to permit healthy physiologic functioning. Mouth rehabilitation is usually the only alternative choice to full mouth extraction when a loss of harmony has occurred in the dental units and destructive action is taking place in the periodontium and the exposed tooth surfaces. In affecting the change from a disruptive arrangement to a more harmonious one, mouth rehabilitation uses prosthetic methods instead of bands and arch wire. This would make this form of therapy as different from routine dentistry as is orthodontics.

If we discuss the care of automobiles, we speak of servicing or maintenance and overhauling. If we wash a car, we help protect the exterior. The replacement of a spark plug usually means smoother electrical functioning of the motor. But a poorly functioning motor requires the introduction of new parts plus a proper alignment of all these parts. This is overhauling. Maintenance and overhauling must always be in different categories.

While it can be readily acknowledged that there is much to be desired in the term "mouth rehabilitation," there should be no question that this is a form of treatment that has to be distinguished in the profession as well as in the lay mind from regular maintenance treatment. Indeed, mouth rehabilitation frequently becomes a necessity only because routine dental attention was neglected. An unreplaced, missing, posterior tooth is a frequent cause of complete disarrangement of the dental units requiring mouth rehabilitation for the correction of the resulting deformity.

I am convinced that if mouth rehabilitation is not yet considered one of the special phases of dental treatment, it soon will be. I am equally convinced that when the experts in terminology get to work on it, they will find a term which will express the concept of orthodontic treatment of malrelated tooth units achieved by prosthetic means.

Sincerely yours,
Irving Goldman

News and Notes

ANNOUNCEMENTS

The Pacific Coast Society of Prosthodontists and the American Denture Society will hold a joint meeting at the St. Francis Hotel in San Francisco, Calif., Oct. 14 and 15, 1955.

The Academy of Periodontology will hold its annual meeting at the Sheraton-Palace Hotel in San Francisco, Calif., on Oct. 13-15, 1955. Members of the American Dental Association are welcome. There will be a nominal registration fee.

The National Association of Dental Laboratories will hold its fifth annual meeting at the Ambassador Hotel in Los Angeles, Calif., Oct. 14-16, 1955. All dental laboratory men, dentists, and dental tradesmen are invited to attend this meeting.

The Pan-Pacific Dental Conference will be held at the famed Waikiki Beach immediately after the close of the 96th annual session of the American Dental Association in San Francisco, Calif. A scientific program is combined with a tour of the Hawaiian Islands. Reservations and further information may be obtained by writing the Mainland Office, Pan-Pacific Dental Conference, 3124 East 14th St., Oakland 1, Calif.

The next annual meeting of the American Academy of Crown and Bridge Prosthodontics will be held at the Conrad-Hilton Hotel, Chicago, Ill., Feb. 4-5, 1956.

The next annual meeting of the American Academy of Restorative Dentistry will be held at the Conrad-Hilton Hotel, Chicago, Ill., Feb. 4-5, 1956.

The American Dental Society of Anesthesiology has opened its membership to all members of the American Dental Association who are interested in local or general anesthesia in the dental office. The primary purpose of this society is to improve and advance the art of anesthesiology. Application may be made to Dr. Jay H. Mervis, 510 Walnut Ave., Clairton, Pa.

The Dental Implant Society of Great Britain would like "to get in touch with dental surgeons with experience of implant dentures who are interested in exchanging ideas and experiences, with a view to the successful development of this branch of dentistry." Letters should be addressed to F. B. Trainin, Chairman, The Dental Implant Society of Great Britain, 109 Harley Street, London, W. 1.

The University of Alabama School of Dentistry, in conjunction with the Veterans Administration Hospital in Birmingham, Alabama, is offering one residency in Prosthodontics and one residency in Periodontics.

For further information, write to Dr. Joseph P. Lazansky, Associate Dean, Director of Graduate Education, University of Alabama School of Dentistry, Birmingham, 3, Ala.

The Dental Department of Beth Israel Hospital announces a course in "Occlusal Adjustment" to be given Sept. 28 to Oct. 2, 1955, and a seminar on periodontia, Oct. 31 to Nov. 11, 1955. The courses will be given under the direction of Henry M. Goldman, D.M.D., and Bernard Chaikin, D.M.D. For further information write to Coordinator of Education Programs, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

The Ohio State University College of Dentistry announces a series of postgraduate courses to be presented during the 1955-1956 school year. The enrollment of each course is limited in order to permit intimate teaching.

The schedule of these postgraduate courses is as follows:

Anatomy of the Head and Neck, Dr. Linden F. Edwards, Sept. 19-23, and June 11-15.

Basic Cephalometrics, Orthodontic Staff, Sept. 19-21.

Clinical Oral Pathology and Diagnosis, Dr. Hamilton B. G. Robinson, Feb. 13-17.

Clinical Periodontics, Dr. John R. Wilson, June 11-15.

Complete Denture Prosthodontics, Dr. Carl O. Boucher, Dec. 5-9, Feb. 20-24, and April 9-13.

Crown and Bridge, Dr. Frank C. Starr, April 2-6.

Endodontics, Dr. J. Henry Kaiser, March 5-9.

General Anesthesia, Dr. M. L. Allison and Staff, Oct. 3-7, and May 21-25.

New Advances in Restorative Dentistry, Drs. William Lefkowitz, Harry Postle, and Mr. Ralph Phillips (Indiana University), Sept. 22-24, and May 10-12.

Oral Surgery, Dr. M. L. Allison and Staff, Sept. 26-30, and April 30 to May 4.

Partial Denture Prosthodontics, Dr. Victor L. Steffel, March 26-30.

Pedodontics, Drs. L. S. Pettit and Ben Williams, May 14-18.

Periodontology and Soft Tissue Lesions, Drs. Hamilton B. G. Robinson and John R. Wilson, June 4-8.

For further information and application, write to Postgraduate Division, College of Dentistry, Ohio State University, Columbus 10, Ohio.

The School of Dentistry, University of Pennsylvania, announces the following postgraduate courses:

Oral Diagnosis and Roentgenology, Lester W. Burket, Jan. 2-13, 1956.

Partial Dentures, M. M. DeVan, Nov. 14-19, 1955.

Advanced Practices in Functional Treatment, Ernest R. Granger, Nov. 7-11, 1955.

Precision Prosthesis and Functional Treatment, Ernest R. Granger, Jan. 16-21, 1956.

For information about these and other postgraduate courses, please communicate with Postgraduate Courses, School of Dentistry, University of Pennsylvania, Philadelphia 4, Pa.

Tufts University School of Dental Medicine announces the following postgraduate courses:

D.P.G. 603—Temporary Splinting and Minor Tooth Movement in the Management of Periodontal Problems, Leonard Hirshfeld, Jan. 16-18, 1956.

D.P.G. 703—Full Denture Implants, Norman I. Goldberg and Aaron Gershkoff, Jan. 9-13, 1956.

For further information and application, write to the Director, Division of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

The College of Dentistry, Ohio State University, announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over two academic years and leads to a Certificate of Graduate Dental Laboratory Technologist. For further information, write to the Director of Dental Laboratory Technology, Ohio State University College of Dentistry, Columbus 10, Ohio.